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THE THEORY OF IDENTICAL ELEMENTS

A Critique and Re-interpretation

THE THEORY OF IDENTICAL ELEMENTS

BEING

A CRITIQUE OF THORNDIKE'S THEORY OF IDENTICAL ELEMENTS AND A RE-INTERPRETATION OF THE PROBLEM OF TRANSFER OF TRAINING

BY

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PREFACE

THAT the problem of general education is intimately bound up with that of transfer of training is genally admitted, and so it needs no further elaboration. How far we may be justified therefore, in our faith in the efficacy of the school in promoting worth while attitudes, ideals, habits, and skills which enable the individual effectively to meet the ever-changing demands of life situations, depends upon the extent to which training and experience may be generalized. Of late there has appeared a widespread skepticism over any sort of transfer. We are told that mental functions are so highly specific and independent of one another that training in one of them does not help in meeting or dealing with another. Consequently, the only kind of transfer that is possible is that of doing over again what has been done before in another situation. As Stratton puts it, "What you do to the mind knows its place; it never spreads. You train what you train." This theory of transfer is what we generally call the theory of 'identical elements,' of which Professor Thorndike is the most ardent advocate. The educational corollary of this doctrine is of tremendous significance. It means that the school must discover the specific items of information and the specific reactions which the child will use in life outside of school, and 'make sure that he possesses these and only these.'

The first task of this presentation is to attempt to show that this view of transfer of training is unwarwanted from several standpoints. In the first place, to say that transfer takes place through identical elements is merely a statement of the fact that transfer

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in some sense or other does take place and not an explanation of how transfer takes place. Secondly, the experimental evidence in support of this theory is inconclusive, both from the standpoint of methods and of findings. Thirdly, the theory is based upon psychic atomism and mechanism, which is as untrue as it is incapable of sound practical application. Fourthly, educationally the theory leads us back to the apprenticeship system which is incompatible with the 'democratic ideal.'

This failure of the theory of identical elements to explain how transfer takes place has its fundamental basis in a misconception of the nature of mind or intelligence and of transfer. A mechanistic interpretation of mind, intelligence, and transfer is contradiction in terms. Transfer, as we generally define it, is a process of using old experience in adapting one's self to new problems or situations. This view implies flexibility, both of the situation and of the response, and the process of adaptation is essentially the simultaneous making over of the situation to make it satisfactory and of the reaction to make it adaptive. Thorndike does not make provision for flexibility and modifiability of response and situation for the simple reason that his fundamental conceptions as to the nature of mind are mechanistic.

In our re-interpretation of the problem of transfer we have taken as a point of departure a view of mind, intelligence, and transfer which is consistent with observable facts of behavior and at the same time compatible with the democratic ideal of education. We define transfer, therefore, as the "extension and application of meanings to new problems and situations." The how of the process is the simultaneous making over of the reaction and the situation. The

significance of this view is quite evident. It stresses the idea of flexibility versus the fixity of response; thinking, building of meanings, and formation of concepts versus mere accumulation of knowledge and skills; cultivation of attitudes and ideals versus narrow practical training. When so conceived and applied this theory of transfer of training makes for the realization of the democratic ideal which the school is expected to promote in the pupils.

It will be evident to anyone who reads this manuscript that the writer owes a great debt to his teachers, particularly, Professor B. H. Bode, under whose direction and guidance this study has been undertaken. Besides this, the writer as a foreign student owes to him a great obligation in the matter of English. To Professor E. H. Cameron of the University of Illinois, and to Professor S. L. Pressey of Ohio State University, the writer wishes to acknowledge indebtedness for the light they have given him upon educational psychology. Likewise, to Professor W. S. Monroe of the University of Illinois, the writer wishes to express his appreciation for giving him his first training in educational research. Miss Maud D. Jeffrey of the University Library, and Miss L. Belle Voegelein of the Bureau of Educational Research Library, have extended to the writer unusual courtesies in making available for him material in both libraries. This indebtedness is sincerely acknowledged.

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PART ONE

A Critique of Thorndike's Theory of Identical Elements

CHAPTER I

INTRODUCTION: STATEMENT OF THE PROBLEM

IT is generally admitted that the problem of education is intimately bound up with the problem of transfer of training. How far we are justified in our faith in the effectiveness of education therefore, depends upon the amount and method of spread or transfer of training from one sphere of activity to another. The traditional notion or theory as to the amount and method of transfer is known as 'formal discipline.' As usually stated, this doctrine means that mental power or mastery gained in dealing with one situation is applicable to any other field which calls for the functioning of such power or mastery. The underlying assumption of this theory is that the mind consists of a collection of faculties or powers, such as observation, attention, memory, reasoning, will, and the like, and that whatever strengthens any one of these strengthens it is a whole. For example, training in mathematical reasoning makes one better able to reason in other fields such as in law, in business, or in religion. A quotation from Thorndike will perhaps make the meaning more clear:

> The common view (of transfer of training) is that the words accuracy, quickness, discrimination, memory, observation, attention, concentration, judgment, reasoning, etc., stand for some real and elemental abilities which are the same no matter what material they work upon; that these elemental abilities are altered by special discipline to a large extent; that they retain those alterations when turned to other fields; that thus in a more or less mysterious way learning to do one thing well will make one do better things that in concrete appearance have absolutely no community with it.

> The mind is regarded as a machine of which the different faculties are parts. Experiences being thrown in at one end, perception perceives them, discrimination tells them apart, memory retains them, and so on. By training the machine is made to work more quickly, efficiently, and economically with all sorts of experiences. Or, in a still cruder type of thinking, the mind is a storage battery which can be loaded with will power or intellect or judgment, giving the individual 'a surplus of mind to expend'. General names for a host of individual processes such as judgment, precision, concentration, are falsely taken to refer to pieces of mental machinery which we can once for all get into working order, or still worse to amounts of something which can be stored up in bank to be drawn on at leisure.[1]

The corollary of this doctrine is that education consists in developing these various faculties in much the same way that a muscle is strengthened by exercise. It does not matter greatly what subject matter is used to develop them; the important thing is the exercise. The more vigorous the exercise, the better it is. One reason why mathematics and the classics were considered very important was that they are difficult. They call for a great amount of effort to master them; hence they are an excellent form of exercise. Little attention was paid to the content or practical value of the subject. The important thing is the form of training, the discipline, or the strength of the power that results from the exercise. Having thus trained these powers, the individual is ready to meet any situation that may come in the process of living.

This doctrine enjoyed preeminence for several centuries, and there is ground for the suspicion that even at the present, the majority of teachers, to say nothing of the average layman, still hold tenaciously to this view of mind and its training. It was not until the time of Herbart that this theory was seriously quest-

[1] Lemcke and Buechner. *Educational Psychology.* 1903, pp. 84-85.

ioned, and it was not until James conducted his pioneering investigation in memory that the doctrine was experimentally tested. The first elaborate attempt to deal with the problem empirically was made by Thorndike and Woodworth in 1901. Since then there has grown up a large body of experiments which is unanimous in the finding that the claims of formal discipline are greatly exaggerated. It came out, for instance, that "accuracy in spelling is independent of accuracy in multiplication, and quickness in arithmetic is not found with quickness in marking misspelled words; ability to pick the word 'boy' on a printed page is no guarantee that the child will be able to pick out a geometrical form with as great ease and accuracy." [2]

Other experiments revealed that training in memorizing words did not help in memorizing numbers,[3] training in mathematical reasoning did not mean ability to reason in general,[4] ability to write neat papers in arithmetic was not found to transfer to writing neat papers in other subjects,[5] etc.

As a result of these experimental findings there has developed in recent years a general skepticism concerning any sort of transfer. It is claimed that all training is specific, inasmuch as the mind is not a collection of general powers or functions, such as observation, attention, memory, reasoning, and the like, but that it is the "sum total of countless particular capacities." Furthermore, these capacities are highly specific and

[2] Norsworthy, N. *Formal Training*, New York Teachers Monograph, Vol. IV, 1902.

[3] Thorndike, E. L. Relation between Memory for Words and Memory for Numbers . . . . *American Journal of Psychology*, 2:487-88, July, 1910.

[4] Lewis, F. C. A Study in Formal Discipline. *School Review*, April, 1905, pp. 281-92.

[5] Bagley, W. C. *Educative Process*. Macmillan, 1905, pp. 203-4.

independent of one another. Therefore, the task of education is not to cultivate any general power or faculty, such as the factuly of reasoning, but many special powers of thought about different kinds of facts.

In other words, "the mind is a convenient name for countless special operations or functions. One may train one of these functions or a number of them, but not a faculty in general, attention in general, or observation in general, or reasoning in general. . . . They act almost as though they were insulated from one another; when you have trained one of them, you have trained that limited function and none else. What you do to the mind by way of education knows its place; it never spreads. You train what you train." [6]

On the basis of these experimental findings and theories of the nature of mind and the learning process, Thorndike formulated his famous doctrine of 'identical elements.' According to this theory "a change in one mental function alters any other only in so far as the two functions have as factors identical elements. The change in the second function is in amount that due to the change in the elements common to it and the first. The change is simply the necessary results upon the second function of the alteration of those of its factors which were elements of the first function and so were altered by its training. To take a concrete example, improvement in addition will alter one's ability in multiplication because addition is absolutely identical with a part of multiplication and because certain other processes, for example, eye movements and the inhibition of all save arithmetical impulses, are in part common to the two functions." [7]

[6] Stratton, G. M. *Developing Mental Power.* Houghton Mifflin Company, 1922, pp. 4-5.

[7] Thorndike, E. L. *Opus cit.*, pp. 80-81.

The bearing of this theory on transfer of training is quite clear and unmistakable. Transfer consists in doing over again what we have learned to do before except that it is a part of another situation. For example, having learned to add a column of figures one is more able to do multiplication because addition is exactly identical with a part of multiplication. No other transfer of improvement is possible except in such matter as eye movements, arithmetical impulses, etc., which are also common to both adding and multiplying. Our old faith in general education is thus left without adequate foundation. Education becomes a matter of imparting specific item of information and building up those particular habits which the child will use directly in life. Whereas, formal discipline emphasized form and regarded content as secondary, the doctrine of identical elements emphasizes content and practical values and pays little attention to form.

This emphasis upon content and practical value of subject matter came at an opportune time. We have become suspicious of the value of general education since much of what we learn in school does not seem to function when we meet life situations. Housewives, for example, tell us that most of what they learn in school about house and kitchen work is not used. Hence the saying that all that a prospective bride needs to learn before she gets married is to use the can opener. A professor of engineering once made the statement that in his profession of engineering all he needed to know of mathematics in order to be able to solve his engineering problems were the fundamental processes of addition, subtraction, multiplication, division, and some very simple equations. He said that the time spent in studying higher mathematics, such as calculus, algebra, and analytic geometry was wasted, inasmuch

as "you can get along as well without them as with them." And if we consider the case of language, it is quite obvious that the great majority of people use very little of what they have learned in school. It has been said that what little a person needs of what he learns in school can be taught in a few lessons.

On the surface, the theory of identical elements seems to be plausible, since it is claimed to be supported by experimental evidence; and besides, observation tells us that general education is far from fulfilling expectations. Reflection, however, makes us hesitate to subscribe to this point of view, for two reasons. First of all, it really leaves the problem of transfer where it was, since as will be shown later, it simply provides for smaller faculties under the guise of specific abilities. Secondly, it advocates a type of education and opens to apprenticeship system, which is incompatible with our ideal of democracy. Education according to this doctrine is specific preparation for a more or less predetermined set of activities, thus leaving the child little freedom in determining his future life career. Furthermore, too much emphasis upon the practical does not leave room for logical organization of knowledge which makes for maximum social insight and intellectual interest. Hence, our task in this thesis is, first, to inquire into the justification for such criticism by examining in detail the theory of identical elements, and second, if we find that such criticism is valid, to formulate a theory of transfer of training which will explain how transfer takes place and at the same time be compatible with our ideal of democratic education.

CHAPTER II

THE VALIDITY OF THE THEORY OF IDENTICAL ELEMENTS

THE validity of any hypothesis is determined in the last analysis by its adequacy in explaining what it is supposed to explain. In the present case, the acid test of the theory of identical elements is whether or not it really explains how transfer takes place. By way of approach we may remind ourselves that the traditional doctrine of formal discipline has proved untenable. This latter theory assumed that transfer takes place through the training of faculties, and that a faculty which has been trained in one subject will function in all other subject matter or situations, irrespective of content. This notion, as was pointed out in the preceding chapter, has been given up for two main reasons, namely, that there are no faculties to be trained, and that observation and controlled experimentation have definitely established the fact that the theory does not work according to expectations.

In place of formal discipline Thorndike offers his theory of identical elements which is merely a way of stating that a function which has previously operated in a certain manner along with certain other functions is now operating in precisely the same manner along with a new set of other functions. As Thorndike states it, "One mental function or activity improves others in so far as and because they are in part identical with it, because it contains elements common to them. Addition improves multiplication because multiplication is largely addition; knowledge of Latin gives increased ability to learn French because many of the facts

learned in the one case are needed in the other." [1] In other words, identical elements have to do with content and not with 'powers' or 'faculties.' As to the exact nature of these identical elements and how, by them, transfer may be explained, we will make further inquiry in the latter part of this chapter.

As we have already pointed out, this doctrine of transfer through identical elements is based on the assumption that the mind is by no means a collection of a few general faculties, such as observation, attention, memory, reasoning, and the like, but is the "sum total of countless particular capacities." Consequently, "the task of teaching is not to develop a reasoning faculty, but many special powers of thought about different kinds of facts. It is not to alter our general power of attention, but to build up many particular powers of attending to different kinds of facts." [2]

The meaning of this conception of mind is quite difficult to interpret. The question is essentiallly this: What is the nature of a 'specific ability' and how specific is it? Two possibilities might be suggested. One is that each specific ability is only a smaller faculty and is got by splitting the faculties into as many particular faculties as we wish to. Another is to conceive each specific ability not as a faculty, but as an ability to do a specific act. From this standpoint no two acts involve the same ability no matter how similar they may be.

If Thorndike adheres to the first definition of the nature of specific ability he is back to where he started, namely, faculty psychology and formal discipline all over again. For it should be noticed that dividing each faculty into smaller functions does not get rid of the

[1] A. G. Seiler. *Principles of Teaching.* 1906, p. 243.
[2] *Ibid,* p. 240.

faculty doctrine. If we split a faculty into ten or twenty smaller functions, each one is still a faculty whether we call it a faculty or by any other name, such as specific ability. Nor do we escape the fallacy of formal discipline by just narrowing the range of transfer.

We may be quite sure that Thorndike would not be willing to go back to formal discipline again. There is only one other point of view that is possible and that is to regard 'specific' to mean that each specific ability stands for each specific act, that is, each specific ability is specific as to content and everything else. This notion undoubtedly represents his view, for he tells us that instead of a reasoning faculty we have as many kinds of reasoning as there are instances of data to be reasoned about, and that instead of a faculty of memory we have as many memories as there are facts to be memorized.

In other words, we can disregard the faculties altogether and confine ourselves to the specific acts. Education then becomes training for specific duties, and transfer consists in doing over again what was done before in other situations. This is entirely consistent with what Thorndike says as to the amount and method of transfer. In the passage quoted in the preceding chapter he tells us that "addition improves multiplication because multiplication is largely addition; knowledge of Latin gives increased ability to learn French because many of the facts learned in the one are needed in the other." [3] A function or ability "is general in the sense of occurring again and again in connection with almost anything else." [4]

This notion of specific ability however, is subject to serious criticism. In the first place, since each act is

[3] *Principles of Teaching.* p. 243.
[4] *Educational Psychology,* Briefer Course. p. 181.

so particular that it differs from all others, learning is totally impossible. In the second place, since learning an act does not help in learning the next, there would be no use for learning at all, and consequently there would be no need for transfer. This absurdity is illustrated very well by the following quotation from Professor Meiklejohn:

> What will you say of a theory that the training of the mind is so specific that each particular act gives facility only for the performing again of that same act just as it was before. Think of learning to drive a nail with a yellow hammer, and then realize your helplessness if, in time of need, you should borrow your neighbor's hammer and find it painted red. Nay, further think of learning to use a hammer at all if at each other stroke the nail has gone further into the wood, and the sun has gone lower in the sky, and the temperature of your body has risen from the exercise, and in fact, everything on earth and under the earth has changed so far as to give each new stroke a new particularity all of its own, and thus has cut it off from all possibility of influence upon or influence from its fellows.[5]

Likewise, it would be useless to talk about transfer at all if we adhere to the ordinary notion of transfer. Transfer, as we conceive it, involves adaptation, or change, or flexibility; that is, the old training is not quite adequate in dealing with the new situation. Consequently, transfer of training means the act of using old experience in adapting one's self to new problems or situations.

This definition contains several implications which we should note in order to avoid vagueness in our treatment of the problem of transfer. First of all, where the second situation is absolutely identical with the first, it is nonsense to talk about transfer at all. It would be exactly like saying that training in adding

[5] Is Mental Training a Myth? *Educational Review*. 37:126 fff, 1908.

2 and 3 is transferred to adding 2 and 3. On the other hand, where the second situation has nothing in common with the first there can be no chance for transfer to take place. Consequently, for transfer to take place at all, and for us to talk sensibly about transfer, the second situation must of necessity be somewhat different and yet somewhat the same as the first. This difference and similarity is not only quantitative but qualitative as well. Finally, if transfer is essentially that process of extending or applying the old experience in solving or otherwise dealing effectively with the new problem or situation, then the element of adaptation constitutes the core of the problem. It is, in other words, essentially a process of identifying the new and the old. So, if we are to understand transfer we must seek light on the question of how identification comes about. To say, therefore, that transfer takes place through identical elements is not to explain how transfer takes place, but only to state that transfer does take place.

Thorndike is undoubtedly correct, as we have already pointed out, in saying that there must be some sort of identity between the old and new situation if there is to be any transfer. The problem, however, is not in the presence, but in the nature of the identical factor and how it is recognized as such. Merely to say that transfer takes place through identical elements is only naming a fact and not explaining how it comes about. Consequently, we have to examine the nature of the identical factor and determine how transfer takes place through it.

Thorndike proposes two types of identities, namely, 'identity of substance' and 'identity of procedure.' Transfer through identity of substance simply means that we deal with the same stuff or data in different

situations. Thus a special training in the ability to handle numbers gives an ability useful in many acts of life outside of school classes because of identity of substance, because of the fact that the stuff of the world is so often to be numbered and counted. The data of the scientist, the grocer, the carpenter, and the cook are in important features the same as the data of the arithmetic class.

This substance is apparently an objective, changeless and fixed 'situation-element' which is "general in the sense that it occurs again and again in connection with almost anything else." [6] It is furthermore ready-made, and our neurones react to it in a certain fixed and unvarying way. This fixity of the situation and its appropriate response is clearly embodied in Thorndike's most fundamental principle, namely, that "in the same organism the same neurone-action will always produce the same result—in the same individual the really same situation will always produce the same response." [7]

This is quite in line with his psychology of learning and concept formation. "Learning is connecting, and man is the great learner primarily because he forms so many connections." [8] This notion presupposes two things, a situation-element and a response. Connecting means establishing bonds between situation-elements and reactions. A situation element is a unit in nature which is the same in whatever situation it is found, just as hydrogen is the same whether it is found in water or in sulphuric acid. Consequently, when we say that two situations have identity of substance we mean that one or more of these situations elements are present in both situations, and that we react to them in the same way.

[6] *Educational Psychology*, Briefer Course. p. 281.
[7] *Educational Psychology*. Vol. I, p. 7.

These bonds or connections between situation-elements and responses vary in complexity according to their number and arrangement, from the most simple reflex to the most complex concept. The important thing to be noticed is that the situation-elements are fixed qualities in nature to which man's neurones react in much the same way as ready-made suits are ready to be tried on. There are 'twonesses,' 'fivenesses,' 'roundnesses,' and other kinds of 'nesses' in nature which await notice. But these qualities are bound up with other qualities in different objects. For example, an apple has such qualities as roundness, red-ness, one-ness and so on. Reacting to an apple for the first time means responding to all these qualities all at once. To establish a connection between one of these elements and a reaction is a problem of so arranging and presenting a situation to the individual that the response element occurs all by itself. For example, a connection between the situation-element, roundness and the appropriate response is established, if upon being presented a round object such as an orange, the roundness response occurs by itself, that is, apart from its former concomitants, such as yellowness, solidity, oneness, sweetness, mass, opaqueness, etc. This process is what Thorndike means by abstracting or isolating a response element, or that of making an implicit connection explicit.

How, according to Thorndike, a connection or bond is established between a situation-element and a response is relatively simple. If, for instance, I wish a child to learn the concept of threeness, I simply present to him several groups of three objects such as *3 pencils, 3 knives, 3 oranges, 3 apples, 3 balls,* etc. Notice that all these groups of objects differ (as claimed) in all respects with the exception of the quality of threeness

which occurs in every group. Elongation occurs only twice (in pencils and knives), roundness, three times (balls, oranges, and apples), etc. The quality, threeness, however, occurs five times, that is, in all the groups. The three element of the response is thus "bound over and again" to the "threeness element of the situation."

What happens in the above case as Thorndike points out "is that the response, by being connected with many situations (*3 pencils, 3 knives, 3 oranges, 3 apples, 3 balls*) alike in the presence of the element (3-ness) in question and different in other respects (elongation, one-ness, roundness, shape, color, yellowness, etc.) is bound firmly to that element (*3-ness response*) and loosely to each of the concomitants (*pencils, knives, oranges, apples, balls*). Conversely any element is bound firmly to any one response that is made to all situations containing it and very, very loosely to each of those responses that are made to only a few of the situations containing it.

We have no difficulty in explaining what Thorndike means by identity of substance. It is not, however, as easy to understand the meaning of identity of procedure. We are told that transfer by identity of procedure is the carrying over of a habit that has been acquired in one connection to another situation. For example, "The habit acquired in a laboratory course of looking to see how chemicals do behave, instead of guessing at the matter or learning statements about it out of a book, may make a girl's methods of cooking or a boy's methods of manufacturing more scinetific because the attitude of distrust of opinion and search

[8] *Educational Psychology.* Vol. II, p. 54.

[9] *Educational Psychology.* Vol. II, p. 44. (Material in parentheses added by present author.)

for facts may so possess one as to be carried over from the narrower to the wider field." [10] Here the data are different, but the mode of procedure is the same. In one case the data consists of "looking to see how chemicals do behave, instead of guessing at the matter or learning statements about it out of a book." In the other case it is either "the girl's methods of cooking" or "the boy's methods of manufacturing." The identical element that may be transferred is "attitude of distrust of opinion and search for facts."

The question at once arises, how the "attitude of distrust of opinion and search for facts" is transferred from a laboratory course to cooking or manufacturing. Thorndike does not give us any explanation. However, there are only two possibilities. It happens either automatically or through a process of reconstruction or making over of the reaction to be transferred. If it happens automatically identity of substance and identity of procedure are the same, and there would be no need of distinguishing them. Furthermore, automatic transfer of a habit from one situation to another is like formal discipline. It would be like saying that reasoning in mathematics is transferred automatically to reasoning in law. In either case, it does not explain how transfer takes place. It is only a statement of fact and not a description of the process of transfer. The problem of transfer lies precisely in the question how the "attitude of distrust of opinion and search for facts" is carried over from the laboratory to the kitchen and the shop . And to say merely that this happens automatically, that is, the new situation just sets off the old habit, is to oversimplify the problem. The laboratory and the kitchen are two different situations, and consequently, the old

[10] *Ibid.* p. 245.

habit has to be re-made to fit the new situation. This re-making of the old habit to meet the demand of the new situation is transfer, and Thorndike does not tell us how it is done.

There remains the other possibility, namely, that transfer involves the reconstruction of a habit or the making over of meanings to fit the new situation. But this position is incompatible with Thorndike's whole psychology, and besides, it conflicts with the notion of identical elements. Thorndike's fundamental principle is that of mechanism. "In the same organism the same neurone-action will always produce the same result—in the same individual the really same situation will always produce the same response."[11] We see at once that if this is the case, there can be no need of reconstruction since, given a stimulus, the reaction just goes off as the gun discharges when the trigger is pulled. Reconstruction involves the making over of a reaction, which means that it is re-directed or modified in a certain way.

The upshot of the whole discussion of transfer through identity of substance and identity of procedure is that the notion of fixed identities is untenable from all points of view. And besides, the problem of transfer disappears because transfer involves flexibility, modifiability, and enrichment of experience. The notion of fixed identities is untenable because there are no ready-made situation elements in nature to which we react with ready-made responses. The situation elements as well as the responses are constructs. They are flexible and modifiable and not fixed and unchanged.

Take a very simple case which is supposedly a fixed content such as the number 3. Is it an absolute, fixed

[11] *Educational Psychology.* Vol. I, p. 7.

and changeless content? Thorndike would say that it is because 3 is always 3 wherever you find it. Such is not, however, the case. The number 3 is the product of an elaborate process of invention. It did not exist before the number system was invented, and certainly it has undergone a considerable change of meaning since then. Every invention of mathematical concept modifies the concept 3. Take the case of the negative and imaginary numbers. Before negative numbers were invented, three-ness always implied a physical correlate, viz., three apples, three oranges, etc. But do we have a -3 apples or a -3 oranges? The invention of imaginary numbers was even more revolutionary. If -3 apple is unthinkable, $\sqrt{}$ -3 apple is even more so. Indeed, $\sqrt{}$ -3 alone is puzzling to the child.

If that is the case, "threeness" cannot be got by isolating it from varying concomitants. It is impossible to isolate it if we want to. Thorndike tells us that by presenting several groups of 3 objects such as 3 pencils, 3 books, 3 oranges, 3 apples, 3 knives, etc., 3 occurs as many times as there are groups of objects while the other qualities such as roundness in the apple and in the orange, elongation in the case of the pencil and knife, do not occur as often. The response threeness being "bound over and over again" to the threeness element of the situation, is "bound firmly to that situation and loosely to each of its concomitants." But a moment's reflection makes this argument fall by its own weight. Is it true that 3 is the only quality that occurs as many times as there are groups of objects? Does not each object possess mass, color (in general sense), area, or surface? Does not one-ness occur in every object? All these qualities occur 3 times as frequently as "threeness" and for that reason, they should be isolated before threeness will be.

Thorndike might explain this anomalous position by reference to the set. He would say that by 'setting' the mind of the child to 'how many-ness,' 'three-ness' gets an advantage over the other qualities like 'roundness,' 'opaqueness,' etc. This explanation, however, is likewise untenable for two reasons. I said before that one-ness is a quality of each object and occurs three times as often as threeness. One-ness is just as much a measure of quantity as threeness is, and if that is the case, setting the mind of the child to attend to how many-ness will mean setting it to one-ness as well as to the three-ness.

There is a more fundamental objection to the question of set as a conditioning factor in isolating a response in preference to others, and that is, it presupposes that the child already possesses the concept of 'number system' in some form. To say that the child's mind is set so that he attends to the situation-element threeness is begging the question, since it is impossible to attend to a quality like threeness unless the response appropriate to it is already isolated from its concomitants.

Take another example, such as the color red. Is there a fixed, absolute, and unchangeable quality as redness which awaits notice? And is it got by isolating if from various red objects such as apple, book, blood, carnation, etc? First of all, the redness of the apple is not the same as that of the book, of the blood, and of the carnation, and presumably the redness of a particular apple is not the same as that of another apple of the same kind. There are as many kinds of red as there are intervening red colors between the brightest and the dullest red. Besides, red colors differ in richness or saturation. There are then as many red colors as there are objects since no two are abso-

lutely identical. If that is the case, redness as a fixed and absolute quality of an object does not exist; and consequently, we cannot get it by a process of isolation from varying concomitants.

What is true with regard to isloating response elements such as threeness and redness holds in the case of abstracting reaction like "attitude of distrust of opinion and search for facts," or in any other form of behavior. There is no situation element to which an "attitude of distrust of opinion and search for facts" is absolutely bound up. Furthermore, if there are such elements they differ so radically from one another like shades of red that there can be no way of providing varying concomitants. Hence, abstraction would be impossible.

As a matter of fact, sense qualities, number concepts, and all kinds of identities are inventions, constructs, and achievements. Threeness is threeness only because of its meaning, and as these meanings are enriched and reorganized and modified our concept of three becomes enriched. For example, the number 3 is the third in the series of numbers 1, 2, 3, 4, 5, etc. It is between 2 and 4; it is ½ of 6, 1/3 of 9, twice 1½, and three times 1. It is a number which when preceded by a minus sign represents many things, viz, 3° below zero, a negative quantity, a descending order of magnitude, etc. When preceded by a minus sign and inclosed in a radical ($\sqrt{\ }$ -3) it means a transcedental number which might be represented by a polar coordinate and which has an enormous significance to the science of electricity and magnetism. As these meanings are invented the previous meanings are reorganized. As we have already indicated, the invention of the negative and imaginary numbers has revolutionized our whole notion of numbers. Numbers are no longer

to be thought of as necessary qualities of physical objects, for obviously we cannot have a -3 apple or a $\sqrt{-3}$ orange; we cannot look out of the window -3 times or $\sqrt{-3}$ times.

The final conclusion that we are led to in this chapter is that Thorndike's theory of identical elements either has to explain transfer of training as formal discipline does, or else it explains it away. If by specific ability Thorndike means a subdivision of a faculty, he is back to where he started, namely faculty psychology and formal discipline all over again. A small faculty is still a faculty whether we call it a specific ability or by some other name. Consequently and logically, transfer takes place through the training of faculties.

On the other hand, if by specific Thorndike means a specific ability for each specific act, the problem of transfer is impossible and unnecessary. But, the existence of transfer is undoubted in the sense that we use old experience in our dealing with new situations. This fact must be explained in some way but to account for this by saying "identical elements" is to name the problem, not to xeplain it. For, as we said before, transfer is essentially that process of identifying the new and the old, and consequently an hypothesis that does not explain how this process of identification comes about is inadequate. The theory of identical elements not only fails to give an explanation of how identification takes place, but it also assumes that which is to be achieved, namely, making the new and the old identical.

CHAPTER III

EXPERIMENTAL BASIS OF THE THEORY OF IDENTICAL ELEMENTS: GENERAL CONSIDERATIONS

IN the preceding chapters I have tried to show, first, that the theory of identical elements is either just a restatement and not an explanation of how transfer takes place, or else that the theory is based upon a highly questionable assumption as to the nature of mind and intelligence. However, since these considerations are wholly theoretical, we need to resort to experimental facts to verify them. We can theorize as much as we wish, but the end result will be theory. We cannot get facts by assumptions any more than formal disciplinarians could obtain mental training by merely assuming it to be a fact.

We shall therefore consider in detail the experimental evidence that we can find. Thorndike's most lasting contribution to the discussion of transfer of training lies in his numerous and varied experiments for the determination of the extent and method of transfer, and his insistence upon scientific procedure as a method of verifying any hpothesis which aims at the solution of the problem. He has shown conclusively, I believe, that the amount of improvement effected by practice directly is greater than the amount of indirect or transfer effect. It is the aim of this chapter to give an account of some of the experiments which Thorndike offers as supporting evidence of his theory of identical elements.

1. The first experiment [1] was made in collaboration

[1] The Influence of Improvement in One Mental Function upon the Efficiency of Other Functions, *Psychological Review*, 8:247-61; 384-95; 553-64, 1901.

with R. S. Woodworth. It was reported in a series of three articles in the Psychological Review, V. 8, 1901. The general problem is to detrmine "the influence of training in one mental function upon the efficiency of other functions." This general problem was divided into three sub-problems as follows:

(1) To find "the influence of certain special training in the estimation of magnitudes on the ability to estimate magnitudes of the same general sort, i. e., lengths or areas or weights, differing in amount in accessory qualities (such as shape, color, form) or in both."

(2) To find "the influence of training in observing words containing certain combinations of letters (e, g, s, and e) or some other characteristic on general ability to observe words."

(3) To find "the influence of special training in memorizing on the general ability to memorize."

The general method consists of first ascertaining the initial ability status of the subjects in the influenced function. This is followed by an intensive training in another function until high degree of proficiency is attained. Then the subjects are tested in the first function to find out the extent, if any, in which the subjects show increased facility as a result of their training in the other function. Thus, in the first problem, the subject's accuracy in estimating magnitudes, e. g., lengths of lines, is determined. He is then given practice in estimating lengths within certain limits until he attains a high degree of proficiency. This is followed by a re-test in the influenced function to find out the extent to which he has profited from the training. In the second problem, the subject's speed and accuracy in picking out and marking certain letters,

words of certain lengths, geometric figures, misspelled words, etc., is determined. Again, he is given practice in picking out and marking words of some one special sort until he attains a high degree of proficiency. As before, he is re-tested in the preliminary function. The results of experiments are stated by Thorndike as follows:[2]

Individuals practiced estimating the areas of rectangles from 10 to 100 sq. cm. in size until a very marked improvement was attained. The improvement in accuracy for areas of the same size but of different shape and from 140 to 400 sq. cm. in size, the improvement was 52 per cent as great.

Training in estimating weights of from 40 to 120 grams resulted in only 39 percent as much improvement in estimating weights from 120 to 1,800 grams. Training in estimating lines from .5 to 1.5 inches long (resulting in a reduction of error to 25 percent of the initial amount) resulted in no improvement in the estimation of lines 6 to 12 inches long.

Training in perceiving words containing *e* and *s* gave a certain amount of improvement in speed and accuracy in that special ability. In the ability to perceive words containing *i* and *t*,, *s* and *p*, *c and a*, *e* and *r*, *a* and *n*, v and *o*, misspelled words and A's, there was an improvement in speed of only 39 per cent as much as in the ability especially trained, and in accuracy of only 25 per cent as much. Training in perceiving English verbs gave a reduction in time of nearly 21 percent, and in omissions of 70 percent. The ability to perceive other parts of speech showed a reduction in time of 3 per cent, but an increase in omissions of over 100 percent.

These experiments showed very clearly the influence of: The acquisition, during the special training, (1) of ideas of method and habits of procedure and also (2) of facility with certain elements that appeared in many other complexes. Instances of (1) are learning, in the 10 to 100 sq. cm. training series, that one has a tendency to overestimate all areas and consciously making a discount for this tendency, no matter what the size or shape of the surface may be; learning to look especially for the less common letter (e. g., *s* in the case *of e-s* words, *p* in the case of *s-p* words) in the training series and adopting the

[2]*Educational Psychology*, Vol. II, pp. 397-99.

habit for all similar work; learning to estimate areas in comparison with a mental standard rather than with the objective 1 sq. cm., and 100 sq. cm. squares which each experimenter had before him (after one gets mental standards of the areas he judges more accurately if he pays no attention whatever to the objective standards). An instance of (2) is the increase of speed in all the perception tests through training in one, an increase often gained at the expense of accuracy.

In conclusion the authors point out that:

Improvement in any single mental function need not improve the ability in functions commonly called by the same name. It may injure it.

Improvment in any single mental function rarely brings about equal improvement in any other function, no matter how similar, for the working of every mental function-group is conditioned by the nature of the data in each particular case.

The very slight amount of variation in the nature of the data necessary to affect the efficiency of a function-group makes it fair to infer that no change in the data, however slight, is without effect on the function. The loss in the efficiency of a function trained with certain data, as we pass to data more and more unlike the first, makes it fair to infer that there is always a point where the loss is complete, a point beyond which the influence of the training has not extended. The rapidity of this loss, that is, its amount in the case of data very similar to the data on which the function was trained, makes it fair to infer that this point is nearer than has been supposed.

The general consideration of the cases of retention or of loss of practice effect seems to make it likely that spread of practice occurs only where identical elements are concerned in the influencing and influenced functions.[3]

II. The sceond experiment was conducted in collaboration with H. A. Aikens and with the assistance of Elizabeth Hubbell and reported in the *Psychological Review*, 1902, Pages 374-82. The general problem was to find the correlations among perceptive and associative processes. Six different tests were given by one person to 160 boys and girls in the eight grade and to 80 in the fifth grade. These tests were:

[3] *Psychological Review*, Vol. II, p. 250.

(1) To mark every misspelled word in a passage.

(2) To mark every word containing *r* and *e* in a passage.

(3) To write the opposites of 20 difficult words such as *stupid, hard-working, strong, save,* etc.

(4) To write the opposites of 20 easy words such as *good, outside, friend, quick,* etc.

(5) To write beside each letter in a column of 15 letters the letter that comes before it in the alphabet. These letters are *f, k, s, p, w, l, e, r, d, o, v, j, n, t,* and *h.*

(6) To perform double-column additions.

Various correlations were obtained between these functions, in accuracy as well as in speed. These correlations vary from zero (the relation between misspelled words marked and R. E. words marked) to 60 [relation of alphabet (efficiency) and easy opposites (efficiency)]. Altogether there were 24 relationships, but since the eighth and fifth-grade groups were treated separately in one-half of the cases and another group of 116 subjects was added in one instance, a total of 37 correlation coefficients were obtained. The following table shows the different degrees of relationship.

TABLE I

RANGE AND FREQUENCY OF CORRELATION COEFFICIENTS BETWEEN THE DIFFERENT FUNCTIONS

Range	Frequency
0 — .10	16
.11 — .20	6
.21 — .30	2
.31 — .40	1
.41 — .50	11
.51 — .60	1
	37

Thus it is shown that 24 or about 65 percent of the correlations are .30 or below, and 35 percent are above .30. The median correlation is .20 and the mean is .212.

In conclusion the authors point out that "The results reinforce the evidence showing that functions apparently closely similar may really be to a large extent independent specializations. For instance, the ability to call up quickly the opposites of 'good,' 'rich,' 'heavy,' etc. is by no means identical with the ability to call up quickly the letters coming before *c, k, t,* etc., or with the ability to call up quickly the answers 7+4, 11+9, 20+6, etc. 'Quickness of association' as an ability determining the speed of all one's association is a myth. Quickness in noticing words containing the two letters *r* and *e* does not to any appreciable extent involve quickness in noticing words grossly misspelled, nor does the accuracy in the one involve anything like equal accuracy in the other. The attention and discrimination required in the two cases must therefore be two different things." *(p. 375.)*

III. The third experiment[4] is a revision of previous results such as those of Wissler[5] and Thorndike[6] and deals with finding the relation between "(1) accuracy in drawing a line to equal 100 mm. line and (2) accuracy in drawing a line to equal a 50 mm. line." It is noted that "Wissler, using a single trial with a 50 mm. line and its bisection, found a correlation (Pearson coefficient) of only .38." Thorndike's records comprised 30 trials for each length with 37 individuals,

[4] A Note on the Specialization of Mental Functions with Varying Content, *Journal of Philosophy,* Psychology and Science Method, 6:239-49, 1909.

[5] The Correlation of Mental and Physical Tests, *Psychological Review.* Mon. Supp. No. 16, III, 1901, p. 62.

[6] Heredity, Correlation and Sex Differences in School Abilities, Columbia University *Contribution to Philosophy,* XI, No. 2, 1903, p. 60.

young women from 19 to 23 years old; all in the same class in the New York Training School.

The following correlations were obtained: *(p. 239.)*

Average error of first 15 100 mm. lines with average error of first 15 50 mm. lines +.655.

Average error of first 15 100 mm. lines with average error of second 15 50 mm. lines +.533.

Average error of second 15 100 mm. lines with average error of first 15 50 mm. lines +.432.

Average error of second 15 100 mm. lines with average error of second 15 50 mm. lines +.471.

Average error of first 15 100 mm. lines with average error of second 15 100 mm. lines +.642.

Average error of first 15 50 mm. lines with average error of second 15 50 mm. lines +.642.

Average error of 30 100 mm. lines with average error of 30 50 mm. lines +.582.

The importance of this result lies in the failure, even after correction of perfect correlation between the function of equalling a 100 mm. line and that of equalling a 50 mm. line. The resemblance denoted by r = .77 is not very close. For instance, we may say that a man's ability to equal 100 mm. lines is little or no more like his own ability to equal 500 mm. lines than it is like his twin brother's ability to equal 100 mm. lines. Such a state of affairs seems preposterous. But the fact remains and until more elaborate measures are made, it must apparently be accepted. Nor is it without corroboration. Woodworth and Thorndike found that training in estimating short lines ½ to 1½ inches) did not spread at all readily to estimating long lines (6 to 24 inches). Recent studies of the behavior of the eye give the possibility that the physiological events may be more different in the two cases than has been supposed.

But if accuracy of discrimination of length means something radically different when the length is 50 mm. from what it means when the length is 100 mm., does it not appear that our descriptive names for mental functions are very inadequate? If the variations with content of the processes to which we give the same name are so great this simple case would make them out, should not the psychologist make content a matter of prime importance for study? *(p. 239-40.)*

IV. The above experiments deal with relatively simple functions. Other experiments pertain to more complex processes such as are involved in the study of school subjects, as for instance, reasoning. In 1922 Thorndike reported a study on "the effect of changed data upon reasoning." [7] The method is very simple and clear-cut, and may be stated in Thorndike's words:

Consider the two sets of tasks in algebra, printed below. Each pair of tasks demands the application of the same principle, but the concrete situation in the one case is that with which our ordinary associative habits have been made, whereas in the other case the concrete particulars are somewhat altered. The alterations vary from slight ones, such as using *p* instead of *x*, or b_1+b_2 instead of $x+y$, to a change from a very customary statement of a set of relations to a very rare statement, as in No. 9.

That is, suppose that one is able to solve the problem, 'What is the value of x in $x+3=8$?' How is this ability affected by a change in the question so as to read 'What is the value of p in $p+3=8$? The first problem involves the ordinary or habitual symbols, x, while the second involves a symbol which has not been used as often in this particular case (presumably). Nine such pairs of problems were given as follows:

Habitual	*Changed form*
(1) What is the square of $x + y$?	(1) What is the square of $b_1 + b_2$?
(2) What is the square of a^2x^3?	(2) What is the square of $r^3\ r^2$?
(3) Simplify $4ac + \left(\frac{b^2}{c^2} - \frac{c^2}{d^2} - \frac{d^3}{b}\right)$	(3) Simplify $5a^2b + (b^2 \div c^2)\ (c^2 \div d^3)\ (d^3 \div b)$
(4) What are the factors of $x^2 - y^2$?	(4) What are the factors of $\frac{1}{x^2} - \frac{1}{y^2}$?
(5) Multiply x^a by x^b.	(5) Multiply 4^a by 4^b
(6) Simplify $ac - [a(b+c)]$	

[7] *Journal of Experimental Psychology.* Vol. V, pp. 33-38.

Habitual

(7) Solve $x + y + z = 15$
$2x + y + 3z = 22$
$x + 24 + z = 25$

(8) $e^2 + ef = 8$ What does x equal x

(9) There are 2 numbers. The first number plus 3 times the second number =7. The first number plus 5 times the second =11. What are the numbers?

Changed form

(6) Simplify $p_1 p_3 - [p, (p_2 - p_3)]$

(7) Solve $c_1 + c_2 + c_3 = 15$
$2c_1 + c_2 - 3c_3 = 22$
$c_1 + 2c_2 + 2_3 = 15$

(8) $e^2 + ef = \frac{}{8}$ What does p equal? p

(9) $y = ax + b$
When $x = 3$, $y = 7$ What does a equal?
When $x = 5$, $y = 11$ What does b equal?

Ninety-seven graduate students acted as subjects. The results as to percents wrong or incomplete for the nine tasks where customary associations were favored and for the nine where some change was made were, in order:

TABLE II.

PERCENTS WRONG OR INCOMPLETE AS A RESULT OF CHANGE OF DATA[8]

Problem	*Customary*	*Changed*	*Difference*	*Nature of Change*
1	6	28	22	$x + y$ to $b_1 + b_2$
2	34	47	13	$a^2 x^3$ to $r^1 r^{112}$
3	37½	64½	27	— to ÷ form
4	22	41	14	$x^2 - y^2$ to $\frac{1}{x^2} - \frac{1}{y^2}$
5	55	70½	15½	
6	25	53	28	x^2 to 4^2
7	62	61	—1	ac_1 etc. to $p_1 p_2$ etc.
8	52	53	1	xyz to $c_1 c_2 c_3$
9	16	70	54	x to p form of problem

In conclusion, Thorndike makes the following theorem, "Any disturbance whatsoever in the concrete particulars reasoned about will interfere somewhat

[8] Thorndike, E. L. *Journal of Experimental Psychology*, Vol. V, p. 36.
[9] This item is not included in the original.

with the reasoning, making it less correct or slower or both." *(p. 33.)*

V. The most recent investigation that Thorndike made was reported in the Journal of Educational Psychology in a series of two articles.[10] The general problem is to determine the amount of disciplinary values of high-school studies. For example, what is the relative merit of Algebra as compared with physics or sewing in developing the pupils' ability to think? The method as first planned is quite simple. Two alternative forms of a composite of tests of "general intelligence" in common use plus certain others which would presumably measure the ability to think were given, one in May, 1922, and the other in May, 1923 to 8564 pupils who in May, 1922 were in Grades IX, X, and XI. "Each pupil who took both examinations recorded the subjects which he studied during the school year, September 22, 1922 to June 23, 1923, and the gains made in the test were put into relation with the subjects studied. For example, we compare the gains for the pupils who studied English, history, geometry, and Latin during the year with the gains for the pupils who studied English, history, geometry, and shop work. If other factors such as initial ability, zeal in taking the examination, and special training on its content are properly equalized or allowed for, the difference in the gain represents the difference between Latin and shop work as taught in these schools in general training or disciplinary value or improvement in 'general intelligences,' or whatever a gain in such an examination measures." *(p. 1.)*

But, as Thorndike explains, such procedure could not be followed without modification, for two reasons:

[10] Mental Discipline in High School Studies, *Journal of Educational Psychology*, 15:1-22, 83-98, 1924.

"First, the multiplicity of different programs makes a requirements of tens of thousands of hours of skilled statistical labor. Second, the small number of cases for any one comparison makes its result too unreliable." *(p. 13.)* In order to have valid results, he should have 1600 pupils in a group. But "very few programs would be represented by as many as 50 individuals."

Instead of dealing with individual subjects he grouped them according to two independent criteria, viz., similarity of content and similarity of effect, the assumption being that "the effect of study itself is not, . . . isolated from its effect through its associates."

Consequently six groups of studies were established:

Study I. History, music, shop, Spanish, English, drawing, and business.
Study II. Civics, economics, psychology, and sociology.
Study III. Agriculture and biology.
Study IV. Arithmetic and bookkeeping.
Study V. Geometry, algebra, and trigometry.
Study VI. Latin and French.
Study VIII. Stenography, cooking, sewing, and combined course in sewing and cooking.
Study IX. Chemistry, physics, and general science

The procedure from this time on is essentially the same as has been planned at the beginning. "If we find 500 pupils who take Latin, geometry, French, and Study I (that is, any one or more of the subjects listed under Study I), and 500 others who take Latin, geometry, and chemistry, we may compare the effect of chemistry with Study I."

With such a procedure he arrived at a very unexpected conclusion, namely, that so far as training in

ability to think is concerned it does not much matter what your study.

The result of Table XVI are in pronounced opposition to the traditional view that certain subjects produce much more general improvement in ability to think than others, and that among the subjects taught in high schools, languages and mathematics are the two that do this to the greatest degree. *(p. 94.)*

If we take, on the one hand, our Groups V (algebra or geometry or trigometry) and VI (Latin and French, which it will be remembered made the better showing of the two), and, on the other, our Group VIII (cooking, sewing, and stenography), the best estimate of the greater gain in ability to think, due to spending a quarter of one's time during a high school year upon the former rather than the latter, is a little under 2½ points. This is only a quarter of the greater gain that one makes during a year by being white rather than colored, is less than the greater gain that one makes by being a high school boy rather than a high school girl in these cities, the subjects taken being identical! We find notable differences in gain in ability to think as measured by these tests, but they do not seem to be due to what one studies. Whites gain 23.5 compared with 13.5 for the colored pupils in the same city. The pupils who make scores of 475 to 575 in the sum of 1922 and 1923 tests, gain about 13 points more than pupils who make scores of 175 to 275. When, however, we measure the effects of differences in studies, race and sex and initial ability of the students being equalized, the effects are small and uncertain.

If our inquiry had been carried out by a psychologist from Mars, who knew nothing of theories of mental discipline, and simply tried to answer the question, "What are the amounts of influence of sex, race, age, amount of ability, and studies taken, upon the gain made during the year in power to think, or intellect, or whatever our stock intelligence tests measure, he might even discuss 'studies taken,' with the comment, 'The differences are so small and the unreliabilities relatively so large that this factor which he would be sure was at work would be the intellect already existent. Those who have the most to begin with gain the most during the year. Whatever studies they take will seem to produce large gains in intellect.

The effects are also qualitatively not what the traditional

theories would expect. The order of Table XVI is arithmetic and bookkeeping, first; physical science, second; algebra and geometry, third; Latin and French, fourth; physical training, fifth; the group composed of civics, economics, psychology and sociology is sixth; one miscellaneous group of history, music, shop, Spanish, English, drawing, and business (Group IV) is seventh; dramatic art, cooking, sewing, and stenography, and biological sciences are last. This order seems less satisfactorily explained by the traditional theory than by a mixture of choice, the limitations of our tests, special training and general training. *(p. 95.)*

But even then, the differences are so very small as to be almost negligible. Therefore, whatever one studies he gets about as much disciplinary value as if he studied something else. The important thing is intellect to start with.

We have described five experiments which Thorndike offers as evidence to support his theory of identical elements. The most important thing to notice is that the amount of transfer is very limited even in functions which are very much alike, such as the estimation of magnitudes. Consequently, it appears as if mental functions were specialized and highly specific. Whether or not that is really the case, remains to be seen in the following chapters.

CHAPTER IV

GENERAL SURVEY OF EXPERIMENTAL INVESTIGATIONS. FINDINGS AND INTERPRETATIONS

WE have given a brief survey of the most important investigations which Thorndike presents as evidence to support his theory of identical elements. This evidence carries with it significance which tends to outweigh the evidence of mere theory to the contrary, for we should grant that the problem of transfer of training will finally be solved by a thoroughgoing analysis and interpretation of actual facts. If we are to question the validity of the theory of identical elements, therefore, we are committed to the task of examining in detail the experimental evidence as to assumptions, methods, results, and interpretations. In other words, it is necessary to test out the theory itself in the light of the facts obtained.

The most conspicuous finding that is indicated by Thorndike's experiments, as well as the most important basis of his theory, is the fact, which he claims to have found, that mental abilities are specific and not general. He draws this conclusion from the results which he finds, namely, that transfer is very limited and that the correlations among mental abilities are exceedingly low,—even, as he points out, in functions which are obviously closely related. Accordingly, he draws the natural conclusion that transfer is to be accounted for mainly by the fact that we do over again in new situations what we have learned to do in connection with other situations.

As was said before, the evidence which he offers is highly convincing. The point that we wish to raise

is this: Is it true that mental abilities are highly specific and not general? To answer this problem we have to raise other problems and determine what answers a disinterested observer might give both in the light of the evidence presented by Thorndike himself and of other facts that might be found, viz., results of other experiments. Several of such problems might be pertinently raised:

(1) Is it true that the amount of transfer is extremely limited? Are the correlations among mental functions relatively low?

(2) Are the assumptions that are implied or stated in Thorndike's procedure verified by his own results and by those of others?

(3) Is his method of procedure entirely valid? Are conditions favorable to transfer present in his experiments?

We propose to answer these questions in the order in which they are given. This chapter will deal with Problem 1, the next chapter with Problem 2, and the following two chapters, VI and VII, with Problem 3.

I. AMOUNT OF TRANSFER AND DEGREE OF RELATIONSHIPS AMONG MENTAL FUNCTIONS

(A) Amount of transfer. As stated above, Thorndike makes his claim of the discreetness of mental functions on the basis of the alleged facts that transfer is limited and that abilities are imperfectly correlated. It is our contention that we have plenty of evidence to the contrary, as will be shown in this chapter.

In 1916 Rugg made a careful survey of thirty transfer experiments and determined the relative amounts of transfer obtained. His findings are reproduced in full in Table III.

The facts that are indicated by Table III can be more clearly disclosed if it is presented in a condensed form as given in Table IV.

In Table III it is quite clear that while 51.05 persent (39.50% + 11.70%) show either slight or no transfer, 23.25 percent of the experiments indicate 'clear evidence of considerable transfer.' The problem that is to be explained is, Why is there is discrepancy? This question will be answered in the next three chapters, although we can anticipate at this point that the reason can be found as we will demonstrate, in the fact that the conditions of the experiments differed. In those experiments which show clear evidence of considerable transfer, conditions favorable to transfer were present, but they were not present in those experiments which indicate very little or no transfer.

In order to bring Rugg's results up to date the writer made a similar study of experiments dating as far back as 1890 to 1927. (For references, see bibliography) Essentially the same results obtain as is shown in Table V.[1]

Table V should read as follows: Take the first column, for instance. Eighteen out of 48 laboratory experiments and 14 out of 51 classroom experiments, or a total of 32 which is 32.32 percent of the 'net total' of experiments (99) indicate considerable transfer, etc.

Among the experiments not included in Rugg's study that indicate considerable transfer are:

1915—Martin, M. A. The Transfer Effect of Practice in Cancellation Tests.[2]

1916—Wang, C. P. General Value of Visual Sense Training in Children.[3]

[1] Comparison of results of experiments as to the amount of transfer is made in Chapter VII.

[2] *Archives of Psychology*, No. 32, 68 pp.

[3] *Educational Psychology Monograph*, No. 15, 85 pp.

TABLE III

Statistical Results of Transfer Experiments (After Rugg, H. O. Experimental Determination of Mental Discipline in School Studies, *Educational Psychology Monographs*, No. 17, 1916, p. 18)

Investigator	No transfer	Statistical evidence doubtful	Slight gains indicate some transfer	Clear evidence of considerable transfer	Experimenter claims large amount transfer, unsupported by evidence	Repetition of experiment shows transfer
Memory Studies:						
James	x		x			x
Peterson			x			x
Ebert and Meumann					x	x
Dearborn, '09						x
Fracker			x	x		
Winch, '08			x			
Winch, '10			x			
Dearborn, '10			x			
Sleight			x			
Sensory and Perceptual Experiments:						
Thorndike and Woodworth			x			
Judd				x		
Coover and Angell		x			x	
Bennett—1 and 3	x					
2 and 4			x			
Scholkow and Judd				x		
Kline			x			
Wallin				x		
Whipple			x			
Foster			x			
Dallenbach			x	x		
Gilbert and Fracker					x	
Jastrow		x	x			
Bair				x		
Leuba and Hyde				x		
Ruger			x	x		
School Activities:						
Bagley-Squire	x	x				x
Ruediger			x			
Bennett	x					
Briggs	*x		x			
Wallin				x		
Rugg				x		

* Doubtful interpretation of data reported.

1916—Hewins, N. P. The Doctrine of Formal Discipline in the Light of Experimental Investigation.[4]

1917—Webb, L. W. Transfer of Training and Retraction.

1919—The Effect of Practice upon Visual Apprehension in the Feeble-minded.[6]

TABLE IV

THE LAST TABLE CONDENSED

Findings	Frequency		Total	Percent
	Lab. Inv.	Class Inv.		
Clear evidence of considerable transfer	8	2	10	23.25
Slight gains indicate some transfer	15	2	17	39.35
Repetition of experiment shows transfer	4	1	5	11.70
Experimenter claims large amount of transfer, unsupported by evidence	3	0	3	7.00
No transfer	2	3	5	11.70
Statistical evidence doubtful	2	1	3	7.00
Total	34	9	43	100.00

1919—Wiltbank, R. T. Transfer of Training in White Rats upon Various Series of Mazes.[7]

1919—Wylie, H. H. An Experimental Study of Transfer of Response in the White Rat.[8]

1923—Haskell, R. I. A Statistical Study of the Comparative Results Produced by Teaching Derivation in the Ninth Grade English Classes of Non-Latin Pupils in Four Philadelphia High Schools.[9]

1924—Johnson, Elsie P. Teaching Pupils the Conscious Use of a Technique of Thinking.[10]

[4] *Educational Psychology Monograph*, No. 16, 120 pp.

[5] *Psychological Review Monograph Sup.*, No. 3, 90 pp.

[6] *Journal of Educational Psychology*, 10:61-82. (Dallenbach).

[7] *Behavior Monographs*, Vol. IV, No. 1, 65 pp.

[8] *Behavior Monographs*, Vol. III, No. 5, 65 pp.

[9] Doctor's Thesis, Published at Philadelphia, 139 pp.

[10] *Mathematics Teacher*, 17:191-201.

1924—Brooks, F. D. The Transfer of Training in Relation to Intelligence.[11]

TABLE V

STATISTICAL RESULTS OF TRANSFER EXPERIMENTS FROM 1890 TO 1927

Findings	Number of Investigations			Percent
	Laboratory experiments	Classroom experiments	Total	
Finds considerable transfer	18	14	32	32.32
Finds appreciable transfer	23	26	49	49.50
Finds very little transfer	1	7	8	8.08
Finds no transfer	1	1	2	2.02
Claims transfer but no data given	1	.....	1	1.01
Claims no transfer but no data given	1	1	2	2.02
Claims no transfer but faulty calculation	.....	2	2	2.02
Finds transference and interference	8	.....	8	8.08
Finds interference only.	3	.....	3	3.03
Grand Total	56	51	107	108.08
Duplication	8	.....	8	8.08
Net Total	48	51	99	100.00

* Includes experiments in sensory and perceptual functions, memory, and experiments with animals.

1925—Hamblen, A. A. An Investigation to Determine the Extent to Which the Effect of the Study of Latin upon Knowledge of English Derivatives Can Be Increased by Conscious Adaptation of Content and Method to the Attainment of this Objective.[12]

[11] *Journal of Educational Psychology*, 15:413-22.

[12] Doctor's Thesis Published at Philadelphia, 81 pp.

1925—Coxe, W. W. The Influence of Latin on the Spelling of English Words.[13]

1927—Meredith, G. P. Consciousness of Method as a Means of Transfer of Training.[14]

1927—Woodrow, H. The Effect of Type of Training upon Transference.[15]

(B) Degree of correlation among mental functions.[16] When we come to the studies in correlation we find the same amount of discrepancy of results. The writer has examined most of the studies that have been made and obtained the following consensus as to the degree of relationship among mental functions.

The evidence as shown above is perfectly clear since 16 or 61.5 percent of the correlations are high, 4 or 15.4 percent are appreciable, and only 6 or 23.1 percent are low.

These results are a clear indication of the fact that while Thorndike's results show a limited amount of transfer and low correlation of abilities, there is plenty of evidence to the contrary. The evidence justifies a doubt as to the validity of the notion that abilities are highly specific and not general. But as we have already stated, by showing that other studies indicate that abilities are general and highly correlated, we have not thereby necessarily shown that the theory of identical elements is false. However, it is obvious that we have a problem, namely, to account for the discrepancy of results. It invites us to inquire, first, whether or not Thorndike's claims are born by

[13] *Journal of Educational Research Monograph*, No. 7, 121 pp. Also in *Journal of Educational Research*, 7:244-47, and in March, 1924.

[14] *The Forum of Education*, 5:37-45.

[15] *Journal of Educational Psychology*, 18:159-72.

[16] It should be understood that we are not assuming that the degree of correlation necessarily implies corresponding amount of transfer. The point that we wish to bring out is that the amount of correlation between two mental functions is, for far forth, a measure of their relationship.

TABLE VI

STATISTICAL RESULTS OF CORRELATION STUDIES[17]

		Frequency	Percent
Finds high correlation		16	61.5
Among mental abilities in general[18]	1		
Among fundamental processes in arithmetic[19]	6		
Between computation and reasoning[20]	3		
Among abilities in school subjects[21]	6		
Appreciable correlation		4	15.4
Among mental abilities[22]	4		
arithmetic[24]	1		
Low correlation		6	23.1
Among mental abilities[23]	1		
Among fundamental processes in			
Between computation and reasoning[25]	1		
Among abilities in school subjects[26]	2		
Between neatness and accuracy[27]	1		
Total	26	26	100.0

his results, and second, whether or not his method of procedure is valid, that is, whether or not conditions favorable to transfer were present in his experiments. These problems will be dealt with in the next three chapters.

[17] For reference see Bibliography on 'Correlation Studies.'
[18] Brown.
[19] Collar, Green, Green, Moore, R. C., Scott, Stone.
[20] Collar, Davies, Moore, R. C.
[21] Brown, McKinley, Rietz, Starch, Weisler, Moritz.
[22] Buckingham, Thorndike, et. al., Weisler, Wyatt.
[23] Carey.
[24] Davies.
[25] Stone.
[26] Carey, Patterson.
[27] Witham.

II. INTERPRETATION OF RESULTS; HOW TRANSFER TAKES PLACE

Thus far we have made a survey of the results of experiments as to the extent of transfer, on the one hand, and the degree of relationships among mental abilities, on the other hand. It would be of interest to know what the consesus of opinion is among investigators as to the explanation of whatever amount of transfer they obtained. In connection with the same study as cited above, Rugg made a tabulation of the judgments of thirty investigators. Table VII gives the results of his analysis.

Rugg interprets his findings as follows:

> By one school of specialists, training has been regarded as specific in effect and transfer has been explained as due to identical ability conditioning factors." However, the typical attitude taken today is that practice may be generalized and transferred through such factors as (1) ideational factors, (2) attention factors, (3) attitudinal factors. Thus, transfer is possible with central functions through the generalization of various ones of these factors. The emphasis here is on making the method of learning a conscious matter, the conscious organization of methods of procedure, the conscious utilization of methods of improvement, better understanding of how to use mental tools, rather than any transferable change (through practice) in the constitution of the organism itself.[28]

While this interpretation was made eleven years ago, it holds today just as well. It is to be noted in this connection that several experiments have been made which had three instead of two groups—one control group and two training groups. One of the training groups practiced in the usual routine fashion in the exercises selected, while the other was given special training in conscious generalization of technique of procedure and organization of facts learned.

[28] Rugg, H. O. *Opus cit.* p. 24.

TABLE VII

The Agencies of Transfer *(After Rugg, Ibid. p. 19)*

	Effect of practice is specific; improvement spreads only through presence of identical elements							Effect of practice may be generalized through							
								Attitudinal factors		Attention factors		Ideational factors			
Investigator	No discussion of agencies of transfer	General claim for identical elements	Identity of content	Identity in procedure	Identity in aim	Specific habits	Perceptual habituation	Recognition of identical elements plus ability to use them	Improvement in methods of learning; technique of learning; tricks of grouping; ideals of method of analysis or attack; conceptualizing abilities	General function of habituation (hypothetical)	Methods of distributing attention	Incr. power of concentration; high level of attention; extending range	Attitudes of orientation and adjustment; familiarity with exceptional conditions	Confidence of success. Central predisposition to meet new situations	Interference operates to block transfer
mes	....	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	....
terson	....	..	..	..	..	..	..	....	x	....	..	.....	.....	.....	....
and Meuman	....	..	..	..	..	..	..	....	x	x	..	x	.....	.....	....
arborn	....	..	..	..	..	..	..	....	x	....	x	x	.....	.....	....
acker	....	..	..	..	..	..	..	x	x	....	x	.....	.....	.....	....
inch, '08	x	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	....
inch, '10	x	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	....
arborn	x	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	....
eight	...	..	x	x	x	..	..	x	.....	....	..	.....	.....	.....	x
and Woodworth	....	x	x	..	..	..	..	....	.....	....	..	.....	.....	.....	....
dd	....	..	..	..	..	..	x	....	.....	....	..	.....	.....	.....	....
and Angell	....	..	..	..	..	..	..	....	x	x	x	.....	.....	.....	....
nnett	x	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	x
and Judd	....	..	..	..	..	..	..	....	x	....	..	.....	.....	.....	x
ine	....	..	..	..	..	..	..	....	.....	....	x	.....	.....	.....	....
allin	....	..	..	..	..	..	..	....	.....	....	..	.....	.....	x	....
hipple	....	..	..	..	..	..	..	....	x	....	..	.....	x	.....	....
ster	....	..	..	..	..	x	..	....	x	....	x	.....	x	.....	....
llenbach	x	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	....
and Fracker	x	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	....
strow	x	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	....
ir	x	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	x
and Hyde	....	x	..	..	..	..	..	....	.....	....	..	.....	.....	.....	....
ger	....	..	..	x	x	..	..	....	x	....	..	x	x	.....	....
gley-Squire	....	..	..	..	..	..	..	....	x	....	..	.....	.....	.....	....
ediger	....	..	..	..	x	..	..	....	.....	....	..	.....	.....	.....	....
nnett	x	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	....
iggs	x	..	..	..	..	..	..	....	.....	....	..	.....	.....	.....	....
allin	....	..	..	x	x	..	..	....	.. x	....	..	.....	.....	.....	....
gg	....	..	..	..	..	x	..	....	x	....	..	x	x	.....	....
	10	2	2	3	4	2	1	2	12	2	5	3	4	1	4
	....	..	..	..	..	..	..	....	19	....	..	.....	.....	.....	....

Such experiments as those made by Coxe, Hamblen, Haskett, Woodrow, and Meredith are illustrations. These experiments are unanimous in their finding that the amount of transfer depends at least as much upon the organization of knowledge, habits, and skills that are to be transferred as upon the amount of practice in the training exercises. We will postpone discussion of this point till later, suffice it to point out that the amount of transfer can be very much increased by so controlling the experiment that conditions favorable to transfer are present. And among these factors are conscious generalization of knowledge, development of meanings and concepts, development of special techniques of procedure, and the like.

Further to substantiate Rugg's findings the writer made another analysis of interpretations including all the experiments on transfer of training that are listed in the bibliography.

Certain conspicuous facts will be apparent in the analysis that is presented below among which are:

(1) The amount of overlapping is great. Thus, we will find Coover and Ruger subscribing to both classifications, identical elements and generalization.

(2) The variety of opinions is staggering. It would seem as though it were hopeless to arrive at even an approximate agreement among our experts.

Despite the great amount of overlapping and the great variety of opinions, it is entirely possible to make a reasonably accurate representation of the judgment of the majority of the investigators, and the writer ventures the suggestion that Rugg's conclusion as cited above is not far from the truth. To the question, therefore, whether or not mental functions can be generalized, the answer is decidedly in the

affirmative. We seem to be warranted in our former conclusion that the most plausible explanation of Thorndike's findings that mental functions are specific rather than general, is that conditions favorable to generalization were absent in his experiments.

DIFFERENT THEORIES OF HOW TRANSFER TAKES PLACE

I. The Effect of Practice Is Specific, and Transfer Takes Place Through Identical Elements.

1. General claim for identical elements.
   a. Coover's 'Common Factor.'
   b. Foster's 'identical ability-conditioning factors.'
   c. Kline and Omen's 'transferable elements.'
   d. Knight and Setzafault's 'common denominator idea.'
   e. Lewis' 'relationship' between subjects.
   f. Martin's 'identity of practice situation and task performed, and of test situation and task performed.'
   g. Poffenberger's 'identical bonds,' 'identity of content and response.'
   h. Reed's 'similarity of special functions and the one specially trained.'
   i. Sleight's 'common elements' 'which must be separable from the complexes in which they occur.'
   j. Wylie's 'identity of maze habits.'
   k. Wallin's 'common elements,' (physiological and psychological).

2. Identity of Content.
   a. Brooks' 'identity of content or processes.'
   b. Coover's 'likeness of material' (objective).
   c. Coxe's 'similarity between English word and Latin word from which it is derived.'
   d. Martin's 'similarity of content elements.'
   e. Poffenberger's, Ruediger's, Starch's, and Thorndike's and Woodworth's 'identity of content.'
   f. Ruger's 'similarity of puzzles.'
   g. Sleight's identity of 'data of material.'
   h. Wallin's 'identity of substance.'

3. Identity of Procedure.
   a. Coover's 'likeness of form' (objective).
   b. Knight's and Setzafault's 'identity of ideas of form.'
   c. Martin's 'identity of practice and task performed.'
   d. Poffenberger's 'identity of response.'
   e. Ruediger's, Starch's, Thorndike's and Woodworth's 'identity of procedure.'
   f. Sleight's identity of 'data of method of presentation.'
   g. Wallin's 'identity of method.'
4. Identity of Aims or Ideals.
   a. Coover's 'identity of purposes or aims and ideals.'
   b. Ruediger's and Wallin's 'identity of aims or ideals.'

II. The Effect of Practice Is General, and Transfers Takes Place through Conscious Generalization.

1. Generalization of methods of procedure.
   a. Judd's 'generalization of experience through constant application.'
   b. Bennett's 'conscious generalization of knowledge' and of 'method of procedure.'
   c. Ruger's 'conscious generalization of methods of attack as in thinking and conceptualizing.'
   d. Coxe's 'generalization of rules and principles.'
   e. Woodrow's 'general technique of memorizing.'
   f. Meredith's 'consciousness of method.'
2. Generalization of Ideals.
   a. Bagley's and Squire's 'theory of conscious ideals.'
   b. Bennett's 'ideals consciously generalized.'
   c. Brook's 'emphasized ideals of procedure.'
   d. Mead's 'conscious generalization of ideals.'
   e. Ruediger's 'indirect improvement of mental function through ideals.'
   f. Ruger's 'ideal of efficiency.'
3. Generalization of attitudes.
   a. Colvin's 'cultivation of generalized attitudes.'
   b. Coover's 'common factor of emotional and volitional attitudes' that are consciously generalized.
   c. Ruger's 'change from self-conscious to problematic attitude, and attitudes of success deliberately planned.'
   d. Saxby's 'development of desire to be more observant.'
   e. Seashore's 'capacity for developing and maintaining perceptual attitudes.'

4. Generalization of habits.
   a. Colvin's 'generalization of habits.'
   b. Mead's 'habits consciously generalized.'
   c. Ruger's 'generalized motor habits.'
   d. Wylie's 'generalized habits.'
5. Application of special techniques consciously generalized.
   a. Special technique of procedure.
      1. Gates' and Taylor's 'acquired technique of procedure.'
      2. Foster's 'more efficient methods of work such as tricks of counting, naming, grouping, etc., and regular and definite procedure as against haphazard unorganized procedure.'
      3. Peterson's 'improvement of method and technique.'
      4. Whipple's 'tricks of grouping.'
      5. Rugg's 'acquisition of specific adjustments to familiar cues of visualization.'
      6. Wang's 'purposive application of method of procedure.'
      7. Webb's 'application of acquired modes of acting.'
      8. Wiltbank's 'application of acquired reactions from one maze to another.'
   b. Improvement of methods of learning.
      1. Colvin's 'improvement of technique of learning.'
      2. Coover's and Angell's 'formation of habits of reacting directly toward a stimulus without useless kinesthetic, acoustic and motor accompaniments of recognition.'
      3. Dearborn's 'changes in the technique of learning.'
      4. Ebert and Meumann's 'general improvement in technique of learning.'
      5. James' 'improvement of one's habitual methods of recording facts.'
      6. Kline's and Owens' 'use of devices in learning.'
      7. Sleight's 'improvement of methods of learning.'
6. Generalization through thinking, conceptualizing, reflection.
   a. Coover's 'intellectual processes,' use of 'simple 'complex,' and 'compound' imagery, 'short circuiting of processes,' etc.

b. Peterson's 'skeletonizing the thought' and the use of analysis.
c. Rugg's 'effectiveness of conceptualizing abilities in developing methods of analysis and attack.'
d. Johnson's 'teaching pupils the conscious use of techniques of thinking.'
e. Fracker's 'conscious recognition of imagery and attention to its use.'

7. Increased power of concentration, high level of attention, equitable distribution of attention, etc.
a. Concentration of attention.
1. Aiken's 'cultivation of attention and concentration upon that which is highest, noblest, and best.'
2. Coover's 'control of attention, in degree, and in duration of concentration.'
3. Coover and Angell's 'power of concentrating attention without distraction.'
4. Cummins' 'concentration of attention upon important task and away from irrelevant stimuli.'
5. Kline's 'concentration of attention.'
6. Kline's and Owens' 'concentration upon certain parts of problem.'
7. Ruger's 'concentration of attention upon problem, search for solution, details, effort, control of physical condition, etc.'
8. Whipple's 'orientation of attention.'
b. Improvement of attention and will-power.
1. Ebert's and Meuman's 'general improvement in attention and will-power.'
2. Lewis' 'education of the will.'
c. Equitable distribution of attention.
1. Coover's 'control of attention in distribution.'
2. Coover's and Angell's 'equitable distribution of attention.'
3. Foster's 'effective facility through extension of range of attention.'
d. Whipple's 'voluntary restriction of observation.'

8. Formation of associations.
a. Reed's 'application of special associative connections.'

b. Wiltbank's 'formation of association between animal's running through the maze to the end of the true pathway and its gaining access to the food box.'

9. Training of faculties (qualified), sympathetic interactions of allied functions, etc.
   a. Belief in restricted or qualified formal discipline.
      1. Aiken
      2. Dallenbach
      3. Hewins
      4. Bair's development of a 'general power to meet an entirely new situation."
   b. Belief in 'sympathetic interaction of allied functions.'
      1. Ebert and Meumann
      2. Radossawljewitch
   c. Frequent exercise of faculty.
      1. Talbot's 'more frequent visualizing.'
10. General orientation to situations.
   a. Bair's development of 'a method of orientation.'
   b. Dearborn's development of 'orientation.'
   c. Foster's 'familarity with material.'
   d. Rugg's building up of 'attitude of orientation.'
   e. Seashore's 'general orientation.'
   f. Sleight's 'familarity with experimental conditions.'
   g. Whipple's 'orientation to conditions.'
   h. Wiltbank's 'overcoming of instinct of timidity and of fear.'
   i. Wylie's 'avoidance of fear reactions and consequent increase in the number and vigor of exploratory movements.'
   j. Webb's 'perception of relationship between two processes.'
11. Integrative functioning of the nervous system.
   a. Wallin's 'integrative functioning of the nervous system.'

The above summary and discussion of experimental results and their interpretations show quite plainly that while some experts, viz., Thorndike, Poffenberger, Lewis, Knight and Setzafault, Sleight, and

others, find that mental functions are highly specific, there is enough evidence from other investigators, Ruger, Rugg, Judd, Coxe, Meredith, Woodrow, Colvin, etc., to show that such functions can be generalized if appropriate technique and method of control of conditions are used. That is to say, the extent and range of transfer is at least as much conditioned by the type of training as by the amount of practice that the subjects have. Further to substantiate the claim, the writer has made comparisons of several groups of experiments, each group of which deals with the same or practically the same problem, and pointed out that the most satisfactory explanation of the discrepancy of results is essentially the same as what we have already pointed out, namely the presence of conditions favorable to transfer in these that indicated considerable transfer and the absence of such factors in these experiments that indicated limited or no transfer. *(See Chapter VII.)*

In the meantime we are committed to the task of making further and more searching examination of the evidence offered in order first of all, to determine whether or not Thorndike's interpretations are born out by the results he gets, and secondly, to inquire into the validity of the method or methods of procedure that he employed in carrying out his experiments.

CHAPTER V

CRITICAL EVALUATION OF EXPERIMENTAL EVIDENCE. A DETAILED ANALYSIS AND EVALUATION OF ASSUMPTIONS IN THE LIGHT OF FINDINGS

WE have thus far given a summary of experimental results, first, as to the extent or amount of transfer, and second, as to interpretation of the way transfer takes place. It has been shown that the amount of transfer is not as restricted as Thorndike claims, and that the majority of the investigators believe that training may be generalized if appropriate methods are used.

To give further evidence of the inconclusiveness of the theory of identical elements I shall attempt to show next that the theory is not strictly in accordance with Thorndike's own findings and those of others which, in my opinion, are highly significant. By way of orientation let us enumerate some of the most important assumptions upon which the theory is based.

(1) The amount of transfer is proportional to the amount of identical elements present in both the influencing and influenced function. To put it differently, the amount of improvement in one mental function as a result of training in another function is directly proportional to the degree of similarity between the two functions.

(2) The second assumption is that a complex act is equal to the sum of its parts, for though an act may be the joint product of several functions, yet each function has been separately acquired, it is set in operation only by one exactly identical stimulus, it produces one

exactly identical response, and it is totally uninfluenced by any other function. That is, two or more functions may frequently operate together, yet each operates in precisely the same manner, whether it is working in isolation or in any combination whatever. Transfer, therefore, is merely a way of stating that a function which has previously operated in a certain manner along with certain other functions is now operating in precisely similar manner along with a new set of other functions.

If such is the case, ability to do the separate acts involved in a complex function means equal ability to do the complex function as a whole, and conversely, ability to do the complex act means equal ability to do the separate acts which compose it.

We will try to evaluate these assumptions separately.

1. The first problem that confronts us is, "Is the amount of transfer proportional to the amount of identity or degree of similarity between the influencing and influenced function. The importance of this problem is quite obvious. Inasmuch as we can find enough similarity between any two mental functions to account for whatever transfer we get, we can justify any result by merely pointing out the identical elements or the absence of such identical factors. For example, if it is found that there is no transfer of training in reasoning from mathematics to law, all we need to say is that law and mathematics are entirely different studies—the data are different, the methods of proof are different, and so on. On the other hand, if it is found that there is a great deal of transfer, one can always say, "Why surely, look at the identical elements. Are not thinking in law and thinking in mathematics the same? In other words, are not Dewey's five steps involved in mathematical reasoning as well as in

law? Don't we sense the difficulty, define the problem, formulate suggestions, evaluate these suggestions, and establish a solution in the light of facts, in both law and mathematics? Isn't the form of the syllogism the same in law as in mathematics? Are not the attitude of suspended judgment and criticism present in both the lawyer and the mathematician? Does not the lawyer as well as the mathematician have to be accurate, precise, clear, and in earnest? Does not the mathematician have to memorize certain rules and principles?"

In other words, we can either minimize or multiply the amount of similarity or identity between any two functions. It is therefore necessary that we should establish some standard of comparison. In most of the cases here cited the relative similarities are so obvious that there is no danger of erroneous interpretations. In many cases Thorndike himself admits that a function is more similar to another than to a third function.

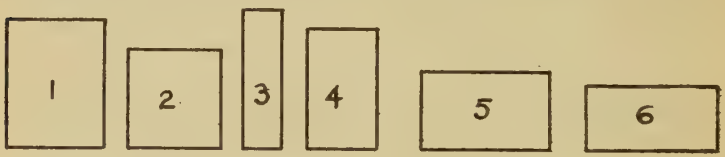
(a) One of the very striking inconsistencies that we find is presented in the very first experiment. It will be recalled that in judging the magnitude of areas of different figures Thorndike and Woodworth tried to determine the influence of improvement in training to estimate magnitudes on the ability to estimate magnitudes of the same general sort except that they differ in qualities such as shape and size, or in both. For instance, they trained six subjects to estimate the areas of rectangles from 10 to 100 sq. cm. in size, and after considerable improvement had been attained, these same individuals estimated areas of figures of the same shape but different in size, of the same size but different shape, and different in both shapes and sizes. If the theory holds, we should expect that the amount of transfer in the case of estimating the areas of figures

of different sizes and shapes would be less than the amount of transfer in the case of estimating areas either of the same size but different shape or of the same shape but different size.

But what results did they get? "Individuals practiced estimating the areas of rectangles from 10 to 100 sq. cm. in size until a very marked improvement was attained. The improvement in accuracy for areas of the same size but of different shape due to this training was only 44 per cent as great as that for areas of the same shape and size. For areas of the same shape, but from 140 to 300 sq. cm. in size, the improvement was 30 per cent as great. For areas of different shape and from 140 to 400 sq. cm. in size the improvement was 52 percent as great." [1]

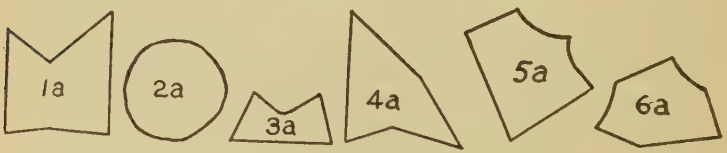
Let us analyze the conditions and results in greater detail.

The practice series consists in estimating the areas of rectangles the magnitudes of which vary from 10 to 100 sq. cm. These areas may be represented by the following figures:



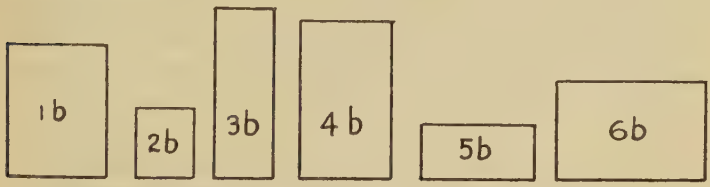
The end tests consist of:

(1) Estimating the areas of the same size but of different shape.



[1] *Educational Psychology.* Vol. II, p. 397.

(2) Estimating the areas of the same shape but different size.



(3) Estimating the areas of different shape and different size.

Note. The figures are merely illustrative and not exact duplicates of what Thorndike and Woodworth used in their experiment. It is to be noted that in Figure I and II, 1 and 1a are supposed to be of the same size but of different shape; in Figures I and III, 1 and 1 b are of the same shape but of different size and shape.

Remember always that Figure I is the standard with which the other figures are compared. Let us arrange Figures II, III, and IV in the order of their likeness or similarity to Figure I. I believe that any one would say that the order is III, II, V. Certainly, IV is more unlike I than either II or III.

If we look at the results, however, the reverse order is obtained as shown below.

TABLE VIII

Showing the Relative Amount of Transfer of Improvement from Training in Estimating Magnitudes to Ability in Estimating Magnitudes of the same General Sort Except in Some Particulars.

	Amount	Order exp'ct'd	Order obt'n'd
Transfer in estimating areas of Fig. II..	44%	2	2
Transfer in estimating areas of Fig. IV.	52%	3	1

That is to say, if the theory of identical elements is true we should expect that the amount of transfer to Figure IV would be less than to either III or II, and that the amount of transfer to Figure II should be less than to Figure III. Note that the order obtained is an entire reversal of what we should expect. Note further that the amount of transfer in Figure IV is almost twice as much as that in Figure III although Figure IV is different in both size and shape from Figure I (standard), while Figure III is different from Figure I only in size.

(b) This point is shown even more clearly in the next article of the same series which the authors summarize in more detail the results of the first experiment. They say specifically in interpreting the figures that "the change in size without change in shape decreases the amount of improvement in proportion, in general, to the amount of change, and that the same tends to hold true when both size and shape change." [2] That is to say, the amount of error in estimating the area of a figure which is 100 sq. cm. in area should be less than the amount of error in estimating the area of a figure which is 200 sq. cm. in area, everything else being equal. Table IX gives the results.

A careful analysis of the table reveals the following facts: First of all, we notice that on the average, the error increases with increase in size in figures which are of the same shape. Thus the errors are 39, 67, and 102 in estimating areas from 20 to 100, 140 to 200, and 200 to 300, respectively. But notice those of indifferent shapes. We have errors amounting to 62, 50, 78, 86, and 77, respectively for areas 10 to 60, 100 to 140, 140 to 200, 200 to 240, and 240 or over. In other words there is great variation in sizes but very little

[2] *Psychological Review*, Vol. V. p. 386.

difference in the errors. The variation in error is so irregular that the difference in result can be attributed to chance. Certainly, we cannot say that there is evidence of proportional transference here. The error in estimating areas of over 240 is less than in estimating areas 140 to 200 and 200 to 240 and the error in estimating an area of 100 to 140 is less than the error in estimating the area 60 to 100.

So far we have dealt with the average. To be thoroughly scientific we cannot be satisfied with the average. After all, there is no average individual. Take the figures under the caption, *Same shape*. We noted above that on the average, the results seem to verify the principle of proportional transference. The errors of subjects *Be* and *Br* follow the trend of the average, but those of subjects *EMT* and *Ber* do not. The errors of *EMT* rise to 140 to 200 from 66 to 602 percent and then drop to 355 at 200 to 300. Ber's case is entirely opposite to the general trend. The best that we can say here is that, on the basis of individual cases, the chances for and against the substantiation of the theory are exactly a 50-50 proposition.

Take the results under the caption, "Different shape" and the result is even more inconsistent with the theory. Not a single subject shows a tendency to vary in number of errors according to increase in magnitude of areas estimated. *Be* has results as follows: CB, EB, 20, 44, 35; *Br* has 85, 39, 146, 139, 121; *EMT* has 51, 34, 129, 83, 87; and *Ber* has 131, 60, 70, 81, 65 corresponding to estimating areas such as 10-60, 100-140, 140-200, 200-240, and 240 or over.

When we come to a final evaluation of the evidence, the chance that the theory holds or does not hold is not even 50-50. We have noted that the theory is substantiated in only one instance out of four. In estimating

TABLE IX

TAKEN FROM THORNDIKE AND WOODWORTH. TABLE IV, *Psychological Review.* VOL. 8, 1901, P. 385

A	Subjects	10—100 in training Series at end	SAME SHAPE						DIFFERENT SHAPE									
			20–100 without Cor. factor		140–200 without Cor. factor		200–300 without Cor. factor		Triangles 10–60		100–140		140–200		200–240		240 and over	
			Before training	After training	Before training	After training	Before training	After training	Before training	After training	Before training	After training	Before training	After training	Before training	After training	Before training	After training
Gross	Be	3.1	21.9	6.4	43.5	20.5	30.2	43.0	14.7	4.7	27.5	14.5	62.6	12.6	63.8	28.0	78.8	27.7
	Br	3.3	21.0	7.7	47.8	26.8	22.0	33.7	10.6	9.0	27.5	16.2	40.3	58.9	57.4	79.7	86.0	104.0
	EMT	2.3	9.0	6.0	5.0	31.0	12.6	44.8	11.5	5.9	37.8	12.8	23.7	30.7	33.8	28.2	52.9	45.9
	Ber	0.4	9.8	4.1	41.6	14.0	*47.4	4.0	4.5	5.9	20.1	12.2	39.6	27.7	47.0	38.0	85.0	55.0
	Total	9.1	61.7	24.2	137.9	92.3*	123.2*	125.5	41.3*	25.5	112.9	55.7	166.2	129.9	202.0	173.9	302.7	232.6
B	Be	56	29		48		143		32		52		20		44		35	
	Br	53	37		56		100		85		39		146		139		121	
	EMT	57	66		602		355		51		34		129		83		87	
	Ber	13	42		34		8		131		60		70		81		65	
Percents	Total		39		67*		102		62*		50		78		86		77	
					3		3		3		3		4		4		4	

* As corrected on Page 553.

areas of different shapes the general trend does not support of the theory. In considering individual cases, the results do not tally with the expectations, because there is an even chance.

And yet we are told definitely "that change in size without change in shape decreases the amount of improvement in proportion, in general, to the amount of the change and that the same tends to hold through when both size and shape change."

(3) In examining other results we find the same consistency, namely, that the amount of transfer does not vary proportionally with the amount of identical elements. Take the experiment on the marking of letters and words. Individuals are trained in marking of letters and words. Individuals are trained in marking out words containing *e* and *s* in printed pages, and then the influence of such training upon cancelling words containing other letters such as *c-a, e-r, A, i-t, s-p, a-n,* and *l-o* and in marking out misspelled words is determined. Who would not say that marking out words containing *es* is more like marking out words containing *c-a, e-r, A, i-t, s-p, a-n,* and *l-o* than *marking* out misspelled words. In cancelling out letters we focus our attention exclusively upon certain particular letters, but in marking out misspelled words we pay attention to the whole word, and instead of noting simply the presence of certain letters we are to note their absence, the presence of irrelevant letters, and the incorrect order of the arrangement of the letters. But again the facts are not in accordance with expectations as the table below will show.

TABLE X.

COMPOSITE TABLE OF IMPROVEMENT IN TEST SERIES—GENERAL TENDENCY

Imp. in	Training series	*i-t*	*s-p*	*c-a*	*e-r*	*a-n*	*l-o*	*e-r*	Misspelled words	*A's*
time	62	79	78	90	86	72	67	79	84	90
errors	50	78	46	74	70	128	150	109	91	36
words marked	115	108	119	107	113	82	89	99	101	103

From the above table we find:

(1) That in time improvement, there was greater transfer to cancelling out misspelled words than to marking out words containing *c-a*, *e-r*, and *A's*.

(2) In errors, there was greater improvement in marking out misspelled words than marking out words containing *a-n*, *l-o*, and *e-r*.

(d) In another investigation which deals with the correlations among perceptive and associative processes [3] we find the same discrepancy between results and interpretation. For example, naming hard opposites is certainly more like naming easy opposites than naming the letter that comes before a given letter in the alphabet. And yet we notice that the coefficient of correlation between hard opposites and easy opposites (efficiency) is .60. Again we notice that in the case of association tests (number done) and addition (number done) there is more than twice as high a correlation for eighth grade pupils as for fifth grade pupils. In the first case $r = .50$ and in the second case it is only .20. The difference here is not due to difference in the amount of degree of identity between the functions considered. If one looks at the table of correlations he will see that there are wide variations, but he will not find evidence of proportional transference.

[3] *Psychological Review*. 9:374-82, 1902.

Of course, as Thorndike himself tells us, "it is . . . often not possible to tell just what features of two mental abilities are thus identical." But, as he also claims, "there is rarely much trouble in reaching an approximate decision in those cases where training is of practical importance." [4] I have therefore selected only those cases in which similarities and dissimilarities are obvious, that is, where there is no difficulty in reaching an agreement.

(e) The next experiment deals with the "effect of changed data upon reasoning." [5] Here we find a clear evidence of the invalidity of the principle of proportional transference. The plan of the experiment in general, as we have already described in Chapter IV, is to compare the efficiency in solving algebraic problems that involve the ordinary letters of x, y, and z and the efficiency in solving the same type of problems if such letters are changed to a, b, p, c, etc. We notice here that a change from the problem 'what is the square of x+y to what is the square of $b_1 + b_2$? involves a loss in efficiency of 22 points. Here the change amounts to two letters, from x to b_1 and from y to b_2 *(see Page 36)*. Notice the change of x to c_1, y to c_2, and z to c_3 in the problem.

Solve:		Solve:	
(1)	$x + y + z = 15$	(1)	$c_1 + c_2 + c_3 = 15$
(2)	$2x + y + 3z = 32$	(2)	$2c_1 + c_2 - c_3 = 22$
(3	$r + 2y + z = 25$	(3)	$c_1 + 2c_2 + c_3 = 25$

Here we have three changes in letters besides another change in sign in equation (2) $2c_1\ c_2 - 3\ c_3$ instead of 2x y 32. But in this case there is an actual gain of one point whereas in the first case in which

[4] *Educational Psychology*, 1903. p. 81.
[5] *Journal of Experimental Psychology*. 5:33-38, 1922.

there were only two changes there was a loss of twenty-eight points!

(f) Further data on proportional transference. This part deals with evaluation of an assumption made by Thorndike very early in his discussion of the theory of identical elements. "The answer which I shall try to defend is that a change in one function alters any other only in so far as the two functions have as factors identical elements. The change is simply the necessary result upon the second function of the alteration of those of its factors which were elements of the first function and so were altered by its training. To take a concrete example, improvement in addition will alter one's ability in multiplication because addition is absolutely identical with a part of multiplication and because certain other processes, for example, eye movements and the inhibition of all save arithmetical impulses are in part common to the two functions." [6] It is the purpose of this section of the paper to cite experimental investigations which give contrary evidence.

(1) The first experiment was made at Columbia University by one of Professor Thorndike's colleagues, Professor Poffenberger, Jr. One section of the paper deals with the influence of training in addition upon ability in multiplication. The result shows interference instead of transference. "Comparing the gains of the trained and control group in the test series, we find the former gained 11.4 seconds and the latter gained 29.7 seconds. Taking the gain of the control group as typical untrained subjects, we find an interference effect from the training amounting to 18.3 seconds.

[6] *Educational Psychology.* 1903, p. 81.

The probable error of this difference is 6.5, making the difference about three times its P. E." [7]

(2) The other investigation was made by Professor L. W. Cole of the University of Colorado on the interference of related mental processes. As this is an elaborate investigation bearing directly upon the problem that was raised in this section it will be described in some detail. Thorndike's assumption could be extended further by saying that ability in subtraction is transferred to division because subtraction is absolutely identical with a part of division. The experiment was performed twice and the findings were essentially the same, so only the first experiment is here described.

The method may be described in the author's words:

In the first series of experiments four persons were practiced in addition and four were practiced in subtraction after a preliminary test in all four fundamental operations. After practice there was a final test of both groups in the four operations. The practice consisted of five periods of forty minutes each. The group worked for ten minutes followed by two minutes of rest. The next ten-minute period was followed by a three-minute rest. The following twenty-minute period was divided by a two-minute interval. Practice was given on alternative evenings except that Thanksgiving recess intervened which separated the last two practice periods by four days. Preliminary and final tests of addition, subtraction, multiplication, and division were each twenty minutes in length and arranged as in the practice series.

Because four persons practiced in each process might be too few for reliable results, we next repeated the experiments with eighteen others, nine to be practiced in addition and nine in subtraction. They were sophomores in college and of those who were studying mathematics an equal number were assigned to each practice group. The results with eighteen persons did not materially change the results with four persons.[8]

[7] *Journal of Educational Psychology.* 6:472.

[8] Unpublished paper. Abstract in Psychological Bulletin for 1925.

The results are reproduced in the following table.

TABLE XI

Showing the gain or loss in accuracy and speed in each of the four fundamental operations by a group of four persons practiced for 200 minutes in addition and for another group equally practiced in subtraction. This is the preliminary experiment.

GROUP A

Group Practiced in Addition Accuracy	Gain or Loss in Problems Correct	Percent of Gain or Loss
Average individual gain in accuracy in addition	3.5	73.6
Average individual gain in accuracy in subtraction	2.25	3.5
Average individual gain in time in subtraction	1.25 min.	6.3
Average individual loss in accuracy in multiplication	6.00	10.0
Group Practiced in Addition Speed	**Gain or Loss in Problems Attempted**	**Percent of Gain or Loss**
Average individual gain in speed in addition	2.00	16.0
Average individual gain in speed in subtraction	5.25	7.5
Average individual gain in time in subtraction	1.25 min.	6.3
Average individual loss in speed in multiplication	2.75	4.4
Average indviidual loss in speed in division	.25	1.8
Group Practiced in Subtraction Accuracy	**Gain or Loss in Problems Attempted**	**Percent of Gain or Loss**
Average individual gain in accuracy in subtraction	3.50	6.2
Average individual gain in time in subtraction	7.20	38.6
Average individual gain in accuracy in addition	0.00	00.0
Average individual gain in accuracy in addition	0.00	00.0
Average individual loss in accuracy in division	0.50	4.8
Group Practiced in Subtraction Speed	**Gain or Loss in Problems Attempted**	**Percent of Gain or Loss**
Average individual gain in speed in subtraction	0.25	0.3
Average individual gain in time in subtraction	7.20	38.6
Average individual gain in speed in addition	1.75	15.0
Average individual loss in speed in multiplication	0.75	1.1
Average individual gain in division	0.00	0.0

Since the results for Group B differed only slightly from those for Group A, I have combined them both in Table XI. The total number is twenty-six persons.

From L. W. COLE—*Unpublished Manuscript.*

The conclusions which are pertinent to our discussion and which are apparent in the above table are:

(1) Both in accuracy and speed those practiced in addition incurred loss in multiplication. In accuracy there was a loss of 6 problems or 10 per cent, and in speed 2.75 problems or 4.4 percent.

(2) Those practiced in subtraction incurred a loss of 4.8 percent in accuracy in division and neither gain nor loss in speed.

(3) In accuracy those practiced in addition showed gain of 1.25 problems in division or 12 percent, but in speed they incurred a loss of 1.8 percent.

(4) Those practiced in subtraction made a gain of 1.7 percent in multiplication in accuracy, but a loss of 1.1 percent in speed.

(5) Those practiced in addition made gains in subtraction of 3.5 per cent in accuracy and 7.5 percent in speed.

(6) Those practiced in subtraction made no gain in accuracy in addition, but made 15 percent gain in speed.

It is not claimed here that the differences are large enough to be of great significance. On the other hand, we cannot say from the above figures that addition helps in multiplication and subtraction helps in division. It is evident that sheer practice in addition does not help multiplication nor does practice in subtraction help in division. The fact is that interference occurs. We may therefore count this evidence as negative and as valuable only in so far as it does not substantiate the assumption that training in addition is beneficial to ability in multiplication because addition is absolutely identical with a part of multiplication.

II. The previous section dealt with the theory of identical elements and the principle of proportional

transference. If the theory holds, we should find that the greater the amount of identical elements the greater the amount of transfer and the variation must be a mathematical variation since Thorndike conceives of the element as being capable of quantitative representation. We found that the theory does not hold, since in some cases where there is greater identity the amount of transfer is less. Furthermore, where proportional transference was held we found no such evidence.

The second problem deals with training in specific habits. We are told that a complex act of attention, for example, can be broken up into specific habits of attending to different kinds of fact. A complex response is the sum total of specific and highly independent responses. If that is the case, having learned the parts of a complex act, the individual should be able to do the whole; and conversely, one who has learned a complex act should be able to do the separate acts with the same facility.

Back of this problem lies a still more fundamental problem which has been raised by the Gestalt school of psychologists. It centers upon the question whether a psychological or experienced whole is equal to the sum of its parts. The significance of this question is apparent from the very start. Thorndike is very strong on the view that the mind is a collection of countless particular reactions, habits, and reflexes. The business of education is to establish these particular habits or connections in order that, given a situation, we may predict the response which the individual will make. It must be remembered that any situation is complex—meaning that it is analyzable into component elements corresponding to particular responses. Likewise, a response is always complex in that it is analyz-

able into a number of specific reactions, the smallest unit of which is the reaction of a neurone.

A schematic representation of this doctrine may be of service in making the assumption more clear. In the following figure (Figure V), S = situation, s_1, s_2, and s_3 are its component elements, R = response, r_1, r_2, and

Figure V

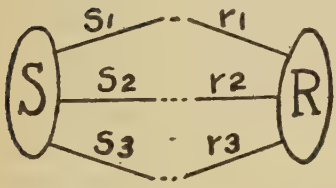
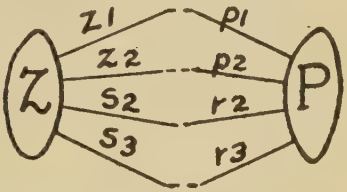


Figure VI

SCHEMATIC REPRESENTATION OF THORNDIKE'S S — R BOND THEORY.



r_3 are its component elements corresponding to the elements of the situation. The assumption is that, given S with components s_1, s_2, and s_3, the individual responds with reaction R via separate reaction systems, r_1, r_2, and r_3. Mastery of S means that the individual has learned to react to s_1, s_2, and s_3 automatically. If, after learning them to react to S by reacting to s_1, s_2, and s_3, another situation is presented which is likewise complex, the individual benefits by the previous experience in amount exactly equal to the number of elements in the original situation that are present in the new situation. For example, in Figure VI above, z is a new situation which contains z_1, z_2, s_2, and s_3 automatically. If, after learning them to react to S by reacting to s_1, s_2, and s_3, another situation is presented which is likewise complex, the individual benefits by the previous experience in amount exactly equal to the number of elements in the original situation that are present in the new situation. For example, in Figure

VI above, Z is a new situation which contains z_1, z_2, s_2, and s_3 elements. The individual should respond with a reaction P by the specific reaction systems or elements p_1, p_2, r_2, and r_3. Having learned to respond to s_2, and s_3 before, r_2 and r_3 are made automatically. Responses to z_1 and z_2 via p_1 and p_2 are learned, meaning the connections between them and z_1 and z_2 are isolated. At first the connections between $z_1 \text{—>} p_1$ and $z_2 \text{—>} p_2$ are only insipient.

From the above analysis it is evident that a situation is the sum of its elements, and so is a response. Learning is a matter of establishing connections or bonds between the elements of a situation and particular responses. If that is the case, it follows that learning to respond to all the component elements, whether such learning has been made by responding separately to these elements or in any combination, means equal ability to respond to the whole situation. To give a concrete illustration,—suppose that S is a puzzle such as one of those used by Ruger in his experiments,[9] and that the solution (response) may be analyzed into parts corresponding to the elements of the puzzle. The assumption is that ability to solve the puzzle means ability to make all the moves that are required. So far, this is perfectly legitimate. Another assumption is that, having learned to solve the different parts of the puzzle, the subject is able to solve the whole puzzle. A third assumption is that, having learned to solve the puzzle as a whole the subject is able to solve the different parts separately. These last two assumptions are not supported by evidence.

Let us take the assumption that learning the separate parts of a puzzle means ability to solve the puzzle as a

[9] Ruger. Psychology of Efficiency, *Archives of Psychology*, No. 15, 1910, 88 pp.

whole. Ruger made a test in which "a subject was tested with a puzzle in a given form. Then all the motor habits necessary for the rapid solution of this form were built up by practice on the separate acts of manipulation involved. The elements were organically related in the successive forms of the practice series, so that the practice was not on the separate elements merely, but on their connections. At the close of the practice series the subject was given the complete form which was identical with that of the initial test. This form was not recognized as being related to the practice series, and the habits built up there were not brought into use."[10]

An example to show the fallacy of the assumption that ability to respond to a whole means ability to respond to the parts separately may be taken from the field of language. Many times we are confronted with words which we can pronounce as a whole, but when it comes to pronouncing a certain part by itself we cannot quite make it. This is usually true in a language which is foreign to the subject. I have tried an experiment with my American friends in connection with the pronouncination of an Ilocano (Philippine) word nga which is roughly equivalent to the conjunction *that*. None of my American friends was able to pronounce it at first, and it takes several repetitions for any one to learn to say it. My procedure is to let the subject say *bring*, or *sing*, or *ring*, and then let him say bringing, *singing*, *ringing*. Then I change the second *i* to *a* and ask him to say *singing-singang*, *bringing-bringang*, and *ringing-ringang*. There is considerable difficulty in the change of *i* to *a*, but the habit is soon established. Then I take out *br*, *s*, and *r*, respectively from *bringang*, *singang*, and *ringang* so that all that is left is

[10] *Ibid.* p. 19.

ingang. My subjects do not have difficulty in pronouncing this. But now, when I take out the *i* and the last *ng* leaving *nga* alone, my subjects invariably say *na*, and it takes a great many repetitions before they are able to say *nga* correctly.

This observation is not controlled, that is, no statistics are given as to the number of repetitions required to learn to say nga, but any one can try it, and I am confident that my observations will be verified.

We have raised the problem whether a complex act or experience is the sum of its parts. Our evidence seems to point to the answer that "a psychological or experienced whole is something more than a mere sum of its parts; in fact, it may even stand in opposition to some of its parts." Learning the parts of a puzzle does not mean ability to solve the puzzle as a whole, and ability to pronounce a word does not guarantee ability to pronounce its parts.

Recent development in the psychology known as the *Gestalt Theory* bears testimony to the fact that an experience is a unique totality. It cannot be broken into parts without changing the entire character of the experience. To say that experience is a unique whole which is complete in itself is to say that it embodies a meaning. The reason why Ruger's subject could not solve the puzzle after learning to solve its parts was due to the fact that the "form (of the whole) was not recognized as being related to the practice series" and consequently, "the habits built up there were not brought into use."

This perception of meanings is apparent even in the apes. Koehler's observations prompted him to say that the apes reacted, not toward the elements of the situation, but toward the situation as a whole.

Every one of the apes in Koehler's laboratory learned to secure a banana out of his reach, beyond his cage, by dragging it toward himself with a stick. But when the conditions were changed so that the ape could secure the banana in this way, as for instance, when the fruit was placed in a drawer, with one of its sides missing, so placed that the open side is farthest from the bars of the cage, then the ape after failing to obtain the fruit in the usual way, suddenly changed his tactics, and pushed the food away from himself out of the drawer and then round it toward himself in a "smooth continuous curve." Koehler points out that the less intelligent apes did not grasp the situation unless the drawer was turned so that the open end pointed more or less toward the side. It is to be noticed that that part of the solution of the problem which consists in pushing the food away is not only contrary to the training and instincts of the animal, but also that taken by itself, it is in conflict with the problem of securing food. Unless, therefore, we abandon the notion of separate elements and regard the whole situation as unique in itself,—requiring unique forms of behavior, we will never be able to interpret or understand the mode of procedure which the animal followed. As Koehler points out, we must assume that the whole situation has a certain configuration or shape so that the solution of the problem is only possible through an insight into configuration.

The phenomenon is clearly illustrated in the case of man's experience of melody. A melody is something that is more than a series of notes. It is a unitary and integrated whole. The same is true with regard to a piece of architecture. A building is made of bricks, iron, sand, wood, tin, stone, etc., but a building is more

than the sum of these substances that compose it. There is a characteristic arrangement of the parts which gives the building a new and unique meaning. Or, take water which can be resolved into two atoms of hydrogen and one atom of oxygen (H_2 O). Water is different from H_2 or O in that it has certain characteristics which are not shared by either hydrogen or oxygen. First of all, it is a liquid whereas hydrogen and oxygen are gases. It freezes at a certain temperature and boils at a certain other temperature.

All these examples point to the fact that when a man or an animal learns to respond to a given situation, his behavior is determined not primarily by the elements of the situation, but by the whole situation, which means an insight into the situation as an integral whole.

A second experiment which demonstrates the fact of insight into the relations within a configuration is even more illuminating than the first. For example, Koehler "first trained an animal to choose the brighter of two grays. After the training had been brought to a successful issue, 'critical tests' were made in which two gray papers were again presented to the animal, so chosen, however, that the previously employed brighter and positive stimulus was retained, while the darker and negative one was replaced with a paper still brighter than the positive stimulus of the training series. There had been no training with the new paper; it was therefore neither positive nor negative. . . . What will the animal do? The new gray is neither positive nor negative, but neutral, while beside it lies a gray strongly positive as a result of many repeated experiments. If the theory of specific response to specific stimulus to be selected in a majority of cases; there would be no reason to suppose that the neutral gray would be more frequently chosen.

"Koehler carried out a long series of experiments of all kind with hens, with chimpanzees, and with a child nearly three years old. . . . The results of these experiments on hens (to say nothing of the chimpanzees and child) contradicted altogether the expectations upon the sensational theory. Among four hens, two of which had been trained to select the brighter, and two the darker gray, the newly introduced neutral paper was selected fifty-nine times out of eighty-five critical tests; whereas the original positive paper was selected only twenty-six times. On the basis of the sensation-theory, the opposite was to be expected; at least, the positive color should have been chosen no less often than the neutral. The presupposition of this theory must therefore be false." [11]

As Koffka points out, the only tenable explanation that we can give is that "the dark-bright pattern, this color-figure, is retained when one passes from the setting of the training-series to that of the critical tests. It can therefore be inferred that, in the majority of cases, the choice was determined by this pattern rather than by the retention of the absolute positive quality of the training-series." [12]

The above experiments of Koehler's reinforce the evidence that I have given from Ruger's experiments on puzzles and from my own observation of my American friends in learning to pronounce *nga* by training in pronouncing *bringang, ringang,* and *singang.* There seems to be no ground for the assumption that response to a complex situation is the sum total of particular responses, but that a situation is an integral whole or a configuration which requires a response that is differ-

[11] Cited by Koffka, *The Growth of the Mind.* Harcourt, Brace and Company. 1924, pp. 139-40.

[12] *Ibid.* P. 140.

ent from the sum of any number of responses to the elements of the situation.

To summarize, the experimental investigations that are cited above contradict two of Professor Thorndike's strongest assumptions, namely,

(1) That the amount of transfer varies mathematically with the degree of identity or similarity between the influencing and influenced function—principle of proportional transference.

(2) That a complex situation is the simple arithmetical sum of its component elements and that a response to it is the numerical sum of the responses to the component elements of the situation—specific ability concept.

CHAPTER VI

CRITICAL EVALUATION OF EXPERIMENTAL EVIDENCE; ANALYSIS AND EVALUATION OF METHODS OF PROCEDURE

WE were concerned in the last two chapters with showing that the experimental evidence upon which the theory of identical elements, and consequently that of specific training, is based, is conclusive. In the first place, contrary to Thorndike's claim that mental functions are highly specific, we have found several experiments which indicate that such functions can be generalized if appropriate methods are used in their acquisition. In the second place, in a great many instances the theory is not in accordance with the facts as revealed by Thorndike's own experiments and those of others. For one thing, the hypothesis of proportional transference is found to be unsupported by Thorndike's own findings. Furthermore, the underlying assumption of Thorndike's psychology, namely, that a complex act is the sum total of specific particular acts and that an individual reacts piece-meal or by parts to any complex situation, does not square even with the behavior of the lower animals, let alone with the behavior of man.

In evaluating the history in the light of the results or evidence that is adduced we have assumed that the method of procedure in arriving at such results is valid. Since the evidence is inconclusive, as pointed out, we are obliged to examine the method or methods of procedure which Thorndike uses in arriving at his results. In other words, we are going to try to find

out the reason or reasons for the discrepancy of the results that we found.

The first question that comes up is whether Thorndike's experiments were so arranged that maximum transfer was possible. Various writers claim that the reason why the amount of transfer has been restricted is traceable to the fact that conditions favorable to transfer have not been created. Says Rogers, "The conditions of the experiments depart so radically from ordinary classroom conditions that it may well be questioned whether results so obtained can determine even approximately the amount of transfer possible in the case of the school subjects. Even where experiments have been carried out in the schoolroom as by Winch and Sleight the methods of securing greatest transfer have not been utilized. It seems reasonable, therefore, to conclude that even if but slight transfer effect has been found in experimental work, judgment against wide spread of improvement in general should be suspended since the conditions favorable to generalization were absent." [1]

It is our contention that in Thorndike's experiments the "conditions favorable to generalization were absent" for the simple reason that the subjects were trained along specific lines so that in the end we cannot expect anything other than specific training. If the aim is the establishment of specific and mechanical habits and the conditions are arranged with reference to this end we cannot expect anything else except by accident—that is, we cannot hope for any degree of generalization except in rare instances.

Let us give an illustration which is familiar to everybody. We have all heard of the bookworm and

[1] Rogers. *Teachers College Record*, Vol. 17, p. 349.

the narrow specialist. A physicist can be so trained and can so train himself along the narrow groove of physics that he will not know anything else when he gets through college. He may get a doctor's degree in that subject, and if he follows it up in his later days he may make notable discoveries in that field. But still this hypothetical specialist, of whom we can find many illustrations, might not know anything outside of physics. Furthermore, while he may know how to apply his knowledge to something purely physical, he is likely to be incompetent when it comes to applying physics to psychology, chemistry, and engineering. A contrary illustration is furnished by the career of William James. He began his study in physiology and anatomy and obtained his first degree in medicine. Later he took up psychology and still later, philosophy. With these funds of knowledge he treated educational problems with the same brilliancy. There are numerous similar cases among eminent as well as mediocre men.

What is the difference? To say that it is due to a lack of identical elements in the first case, and to the presence of such elements in the second would be inadequate for the reason that we still have to account for the fact that they are present in one connection and absent in another connection. Another explanation of the discrepancy might be found in the difference in intelligence. But such explanation is likewise inadequate for the reason that one who is able to get a doctor's degree in such a difficult subject as physics can be assumed to possess a high degree of intelligence. The difference that we can see is, that in the first case, the training tended toward a narrow specialization while in the second case, the experience

has been generalized and applied to situations other than that in which is was acquired.

Examples of simpler types will bring out the point more clearly. Take the matter of learning a foreign language. Why do children learn a foreign language better than adults? I know of an American family that have lived in the Philippine Islands for more than twenty years. Three children were born in Philippine environment in which the language is foreign to this family. Twenty years later they all came back to America. I visited them, and I was ashamed of myself for having a worse pronunciation and enunciation than the children. But when I talked to the parents who have lived in the islands longer than they, the story was different. It might be said that the children spoke the American language just like American children born in America. What is the difference? One might say that the children in their play have had more chance to talk, but I know of an American preacher who has preached in the Philippine dialect for more than twenty years, talked to our people in our language, and associated with us very freely. But his accents and enunciation are entirely different from those of ours.

Thorndike would doubtless explain this fact with reference to the flexibility of the nervous system, and rightly so. But still, such an explanation would be partial. Flexibility implies modifiability and modifiability means re-direction. All these terms denote change in function. For example, it is found that the Filipino children who start learning English at the age of eight or nine have great difficulty in learning to pronounce *the, they, she, thing,* and the like. As a matter of fact, it is found that they never learn to pronounce them correctly. The reason for this diffi-

culty lies not alone in the fact that their nervous system is not flexible enough (for they learn to pronounce other words much more readily), but that they have language habits which interfere. The Philippine dialects contain many syllables like *de, di, si, se, ti,* and so on, the pronunciations of which are as antagonistic, to those of *the, she, thi,* as typing with one kind of keyboard is antagonistic to typing with another kind of keyboard. Conversely, American children who spend a long time in the islands have great difficulty in learning to pronounce such Philippine words involving *de, di, si, se, ti,* and the like because of their previous training in pronouncing *the, they, she, thing,* and the like.

The most plausible explanation that can be given is that the children were trained in the Philippine language before they acquired fixed habits of the English language. As Judd said in one connection, "When training has fixed a habit, all related activities are less open to education than before."[2]

We are all familiar with the difficulty of teaching grammar to children who have acquired bad English before they enter school. Commercial teachers likewise tell us that it is much easier to teach a pupil who has not touched a typewriter than one who can typewrite with facility in the ordinary two-finger method.

In discussing training in observation Judd makes reference to a Greek philosopher who, while looking at the stars, fell into a well which he had not noticed. This fact as he points out does not show that observing stars is independent of observing wells. Rather, it shows that you cannot observe two things at the same time, and if you direct your observation to one

[2] *Educational Review,* Vol. 36, p. 33.

fixed object you must be satisfied in not being able to observe others. As Judd says, "I cannot read books and at the same time look at the sky. No one would argue from this that I have one eye for the reading of books and one for looking at the sky. The simple fact is that I have one pair of eyes and I can use them as I will, but if I use them in one direction (observing of stars) I must be content to turn them away from other directions (observing wells)." [3]

The case of Newton is familiar. Before his time many people have seen apples or other objects fall to the ground, just as many people had seen lamps swing in church and in other places before the time of Galileo. But why wait for a Newton to discover the law of gravitation and for a Galileo to establish the law of pendular motion? Why did not others see what Newton saw and what Galileo saw? Was it because of the absence of identical elements? Was it because Newton and Galileo were far more intelligent than the people who lived before them? We have already pointed out that these explanations are partial and inadequate. If the I. Q. of Plato and Aristotle could be determined and also that of Newton and Galileo I doubt very much if the latter would be found to have higher degree of intelligence than the former. The reason that Plato and Aristitle did not discover the laws of gravitation and pendular motion may be accounted for by the fact that they were not interested along these lines of investigation.

I have given various illustrations of the fact that the manner in which one's training is acquired, one's interest, and a host of other factors have a considerable part in determining whether or not transfer takes

[3] *Educational Review*, Vol. 36, p. 32.

place, and to what extent one profits by previous experience in his dealing with new situations. Let us turn to experimental facts. First of all, we may recall the experiment of Thorndike and Woodworth on the influence of training in marking out words containing certain letters upon the ability to mark out words containing certain other letters. The amount of transfer was found to be very small. Kline performed practically the same experiment and his findings are even more startling, for instead of small transfer he found interference. He "tested seventeen individuals for ninety minutes in all in two days, in marking nouns, verbs, prepositions, etc., on pages of regular English prose. He then had nine of these practice for fourteen days, from thirty to forty-five minutes a day, at marking e's and t's. These nine made a gain of from 31 to 168 percent in the number marked per minute. He then re-tested both groups as before, and found that the practice group was worse off than the control group. Both made gains due to special practice, added interest and the like, but the control group gained the more." [4]

Does the relatively inferior work of the experimental group mean that marking out nouns, verbs, prepositions, etc., is independent of marking out e's and t's? The curious fact that if the two functions were independent the training series should at least not have interfered with the test series. If there is any one thing that is revealed here, it is the fact that the two functions are very closely related and dependent upon each other so that the two almost constitute a unity. Training a function along one line means literally sacrificing plasticity in other lines. Let us quote from Kline himself:

4 Cited by Thorndike, *Educational Psychology*, II, p. 401.

The meaning of the relatively inferior work of the practice group in the second period is best made from the reports of the members of the group. One says: (1) 'In crossing out parts of speech one always had to think what part of speech the word was.' (2) 'The crossing out of the letters became a habit and instead of crossing out words one wanted to cross out e's and t's. These seemed to be seen so much more clearly than the parts of speech.' Another writes, 'The practice with e's and t's hindered me in dealing with the parts of speech. I think it was because I became accustomed to looking for e's and t's and the tendency was to cross out those letters rather than the parts of speech.' A third says, 'There was, however, a tendency to cross out words containing e's and t's rather than the required part of speech.' My own experience tallies with that of the students. The e's and t's got the attention even in irrelevant words. In the right word these letters, if present, were often the only part crossed—this was contrary to our rules of work, a word required a horizontal stroke, letters an oblique stroke. They at times appeared longer and blacker than the other letters. The illusion persisted for six months afterwards. In dealing with the letters our attention was given to mere form and when working with words it was directed to their use or function in a sentence. The letter-habit interfered with the word-marking process and thereby incapacitated it for that manner of work. These results find confirmation in our common life. 'One who has learned to concentrate altogether on the meaning of the printed page finds it extremely difficult, if not impossible, to read proof accurately. And conversely a first-class proofreader is likely to be a slow reader.' [5]

Bergstrom's experiment on the relation of the interference to the practice effect of an association [5] is a very clear case of the influence of habit formation upon transfer. "The experiment consists of sorting eighty cards into ten different piles, each to contain eight cards with the same picture. In sorting the same pack a second time, a given card may be placed in the position which it originally occupied or in one

[5] Cited by Thorndike, *Educational Psychology*, Vol. II, pp. 402-3.
[6] *American Journal of Psychology*, 6:433-42.

of other nine positions." *(pp. 434-35.)* In other words, after training in sorting the cards in one system or arrangement, such arrangement is changed in the next distribution of the cards. The results are stated in the author's own words: "We have shown that under the simple conditions of this experiment, the interference effect of an association bears a constant relation to the practice effect, and is, in fact, equivalent to it." *(p. 441.)* That is to say, the more firmly a habit is fixed the more likely will the training interfere with other related functions. It would be most unwarranted to argue from this evidence that the function of placing a card in a compartment is specific and independent of the function of placing the same card in another compartment; or that the functions of placing different cards in the same compartment are specific and independent of each other. The fact of the matter is that the two activities are one function which, having been trained to do a certain thing, means that such a habit has to be broken before establishing another habit.

With these preliminary considerations we are ready to determine whether or not Thorndike's own experiments were so planned that habits were the outcome. We have already mentioned his experiment on the marking of words containing certain letters and the influence of such training in marking words that contain certain other letters. His experiment on the estimation of magnitudes are subject to the same objections. For instance, he trained his subjects in estimating the lengths of lines .5 to 1.5 inches until considerable improvement was made. Before and after the training he had these subjects estimate the magnitudes of lines of 6 to 12 inches in length. In another connection he studied the relation between

accuracy in drawing a line to equal 100 mm. line and accuracy in drawing a line to equal a 50 mm. line. In the first case there was no advantage of training, and in the second case the resemblance "is not very close." As Thorndike says, "For instance, we may say that a man's ability to equal 100 mm. lines is little or no more like his own ability to equal 50 mm. lines than it is like his twin brother's ability to equal 100 mm. lines." Does Thorndike mean to say that estimating the length of 6 inches is specific and independent of estimating the length of the .5 line? If that is the case, then estimating the length of .5 inch line is independent of estimating the length of say, .00000000001 of an inch. And if we subject the argument to its logical conclusion, the act of estimating the length of a .5 inch line is not really a specific function, but the sum of an infinite number of specific functions which are independent of one another, since such a magnitude can be divided mathematically into infinite number of points. Shall we say then that estimating the length of a line is the sum total of an infinite number of estimations of the magnitude of points? Let me ask the question this way, Does each point have a nerve ending and a cerebral center and a neutral pathway? If that is the case, our nervous system consists of infinite receptors, infinite conductors and infinite connectors. Are we willing to grant this hypothesis?

As long as we are making assumptions we may as well play out our string. If we propose to deal with specific elements, let us be thorough-going. The repetition of an act is not really the same as the first performance if there is any learning at all. Therefore, the first performance is different from the next and the first repetition is different from every succeeding repetition. By the same reasoning, estimating the

magnitude of a .5 inch line today is different from the estimation of such magnitude tomorrow or at any other time. Now let me ask, can transfer of training according to the theory of identical elements take place? The fact of the matter is that there are no absolutely identical factors, such as Thorndike seems to assume. Consequently, there is ground for believing that transfer according to the theory of identical elements does not take place in fact even if it were theoretically assumed to be true.

As a matter of fact, transfer actually takes place, and Thorndike's results, contrary to what he claims, show that it does take place. Estimating the line of a certain magnitude is so bound up with estimating other magnitudes, just as eating beefsteak is bound up with eating any other kind of food such as chop suey. Having trained a function in estimating the length of a line .5 inch long in such a way that the result is a fixed habit, one cannot train the same function in estimating another line without some interference effect. Having been accustomed to eating chop suey all his life our Chinese friend coming to America does not enjoy American cooking. Likewise, Americans unaccustomed to eating foods which have a lot of spices in them are unable for quite a while to eat with satisfaction at Filipino restaurants. Does this mean that eating beefsteak is different from eating chop suey? Such would be an absurd conclusion. The same sense organs are involved just as in Judd's illustration the same eyes are involved in observing wells and stars. But having been used to reacting to one kind of food these sense organs rebel if they are forced to react to other kinds of food. In other words, as Judd points out, "reciprocal interference is just as

significant a type of relation and just as certainly a type of transfer as is joint improvement." [7]

Let us proceed to another of Thorndike's experiments. The one on the "Effect of changed data upon reasoning" is the most interesting, since it deals with practical school situations. Here again, we find what is true in simple mental functions. Let us take the very simple case of finding the square of $x + y$. Thorndike found that by changing x to a_1 and y to b_1 there was an interference of 22 points. From this observation he concluded that squaring $x + y$ is specific and independent of squaring $a_1 + b_1$, and consequently, to be able to square each, different habits have to be established. That is, we should train the individual to square a_1 and b_1 as necessarily as we should train him in squaring $x + y$. Our contention is that the presence of interference indicates that the two are so very closely related that we can almost call them one function. Consequently, training the function along one line of activity, such as solving exercises with x's and y's will interfere with succeeding adjustment, such as dealing with similar problems that involve a_1's and b_1's. This interference effect can, however, be avoided by so generalizing experience that squaring $x + y$ is the same process as squaring $a_1 + b_1$. That is, the meaning of the exercise. Find the square of $x + y$, is the same as the meaning of the exercise, Find the square of $a_1 + b_1$.

It is an undeniable fact that in our conventional high school today and much more so in the past, the type of training that is given in all subjects, especially algebra and geometry, is very highly formal and verbal. The solving of algebraic exercises and prob-

[7] *Educational Review*, 36:29.

lems of the types that occur in Thorndike's experiment is mainly a mechanical juggling of figures in order to get the right answers. There is little reasoning in it of the kind that we call reflective thinking. It is a well-known fact, of which we do not need experimental evidence, that pupils who are proficient in dealing with x's and y's have trouble when it comes to solving problems and exercises containing other letters of the alphabet. The reason is not far to seek. The textbooks use x and y in most cases, and teachers use them too. It is not surprising therefore, to find people who say that they never could get algebra because one day x is 2 and the next day it is 4. In other words, the character of algebra as a generalized language of arithmetic is not realized. Consequently, if asked the reason why algebra is not used more often in life I should say that it has never been tried.

To be sure, we are sometimes taught the general equation $(a + b)^2 = a^2 + 2ab + b^2$, but knowing the formula does not insure generalization except of a very formal and verbal kind. Having learned the formula we are given problems like $(2a + 3b)^2$, or $(4x + 5y)^2$, or even $[(a + b) + (2a + 3b)]^2$. We are puzzled for a time, but then our teacher tells us to apply the formula. We are told in the first problem, for instance, $2a$ takes the place of a, and $3b$ takes the place of b. All we need to do is to multiply $2a$ by itself, also $3b$, and then add to the sum twice the product of 2a times 3b. The same holds in the other exercises. When asked why we do such a thing, all we need to say is that, that is the way according to the formula. There is no reasoning about it. All is formal drill without any meaning. To be sure, drill is indispensable, but if we merely drill, that is, with-

out generalizing our experience in such a way that the result is a genuine discovery and understanding of the principles involved, we cannot hope to make the learning transfer in the solution of other problems and exercises having other letters, much less can we hope to have it function in the solution of problems that are outside the realm of algebra.

The same is true with regard to the other problems listed by Thorndike and in all problems given in the ordinary classroom. The reason why there is interference between squaring $x + y$ and squaring $a_1 + b_1$ is not that the two processes are antagonistic or even lacking in identical elements. The fact is that the habit involved in solving $x + y$ has either to be controlled by meaning that $x + y$ is the same as $a_1 + b_1$, or else it has to be broken before another habit is formed. The idetical element is there but it is not perceived. The result is that having formed one habit means the shutting off of other modes of action that go through the same channel.

The upshot of the above discussion is that mechanical habits are the opposite of transfer and unless they are directed and controlled by meanings or intelligence, they interfere with the acquisition of other habits just as surely as facility of typewriting with two fingers will interfere with learning the touch system, or of training with one kind of keyboard will interfere with learning to operate other keyboards.

But mere theorizing about the influence of meaning and generalization upon transfer without experimental verification is liable to meet a counter objection, namely, How can we show that such is the case? Until the hypothesis is verified by facts, it remains to be proved, and the only way to verify it is either to make an original investigation or else to cite the

experiments of others. Fortunately, there is enough experimental evidence available to serve our purpose.

Such experimental evidence may be divided into two types. One is the sort of experiment in which the same experimenter varies his own procedure and compares the results. The other is the type of experiment in which several individuals in dealing with the same or related problems make independent investigations with varying procedures. We have several experiments of both types.

(a) Judd's experiments. (1) "Two observers were given a series of tests in the comparison of two geometrical figures. The figures compared were complex and were incorrectly perceived because of their complexity, giving rise to what is known as a geometrical illusion. One of the two figures was over-estimated; the other was under-estimated. As a result of a long series of comparisons, the two observers ultimately overcame the tendencies toward over-estimation and under-estimation; that is, they learned to apprehend the lines correctly. They both learned this lesson in about the same number of comparisons showing that they were both at the outset equally capable of taking on the effects of practice. During the course of the experiment one observer was kept in total ignorance of the results of practice, while the other was fully informed. Thus when they entered upon the second stage of experiment, one had practice, but did not know its effects upon him. The other had practice and did know its effects. The figures which they were using for comparison were reversed and a second series of tests began. When they began working with the reversed figures, both observers showed confusion under the new conditions. Very soon, however, the observer who knew about the effects of practice ad-

justed himself to the new demands and rapidly overcame the illusion. There was in this case a speedy and advantageous transfer of practice. The other observer who did not know the effects of his earlier experience showed a greater error than at any time in the first series, and, what is still more important, he showed no disposition to improve. In spite of the difference in the final outcome it should be noted that the practice gained in the first series was transferred in both cases. In one case it worked improvement; in the other, it not only worked against improvement by increasing the illusion, but it also rendered the observer incapable of rapid readjustment." [8]

(2) A second experiment was reported in the same article. At the suggestion of Dr. Judd, Mr. Scholakow conducted an experimental investigation on the effect of knowledge of the law of refraction upon ability to hit a target placed under water. "Two groups of pupils in the fifth and sixth grades were required to hit with a small dart a target which was placed under water. The difficulty of hitting the target arises, of course, from the deflection which the light suffers through refraction. The target is not where it seems to be, and the boy must fit his aim with the dart to conditions which differ from those which he knows in ordinary life. The amount of refraction and the consequent displacement of the target are capable of definite theoretical explanation before one throws the dart. In this experiment one group of boys was given a full theoretical explanation of refraction. The other group of boys was left to work out by experience without theoretical training. These two groups began practice with the target under twelve inches of water. It is a very striking fact that in the first

[8] *Educational Review*, 36, pp. 30-31.

series of trials the boys who knew the theory of refraction and those who did not gave about the same results. That is, theory seemed to be of no value in the first tests. All the boys had to learn how to use the dart, and theory proved to be no substitute for practice. At this point the conditions were changed. The twelve inches of water was reduced to four. The difference between the two groups of boys now came out very strikingly. The boys without theory were very much confused. The practice gained with twelve inches of water did not help them with the four inches. Their errors were large and persistent. On the other hand, the boys who had the theory, fitted themselves to four inches very rapidly. The theory evidently helped them to see the reason why they must not apply the twelve-inch habit to four inches of water. Note that theory was not of value until it was backed by practice, but when practice and theory were both present the best adjustment was rapidly worked out." *(pp. 36-37.)*

The experiment was continued a little bit further to find out how long those without theoretical training mastered the target at four inches below the surface of the water. They did master the four inches, but were again confused with eight inches.

(b) Ruger's experiments.[9] (1) "A given subject was tested with a puzzle thrown in chance positions. He was then trained to approximately the phsiological limit in handling four special but important positions. He developed no general rule to include his treatment of these special positions. He was then re-tested with the puzzle in chance positions. Another subject was trained entirely with chance positions, in a series ap-

[9] Ruger, H. A. The Psychology of Efficiency, *Archives of Psychology.* Vol. 19, No. 2, pp. 18-19, 1910.

proximately half the length of the first subject's series. The second tests of the first subject showed no improvement over the initial results and were inferior to those of the second subject. This failure to profit by the highly specialized training seems to have been due to the lack of generalized rule of procedure. As it was, each chance position was first reduced to one of the four special positions and then the solution was proceeded with instead of being performed directly."

(2) "A certain puzzle was so arranged that it could be presented in various forms. The manipulation for these various forms could all be comprised under a single formula. This general formula could be deduced from any one of these special forms. A number of subjects were tried with this puzzle. As soon as skill was acquired in dealing with one form of the puzzle it was changed to another form. The subjects who developed the general formula during the solution of the first form were able to use the specialized habits built up in the first form in the second. Those who formed merely the special habits without developing the principle attempted to carry over the habits without modification and were greatly embarrassed by the change."

(3) The third attempt was already described and need not detain us, except to say that the procedure was of the same order. Subjects practiced in a puzzle of one form and then were given another puzzle of the same form. The similarity of the two puzzles was not recognized and consequently there was no transfer of training.

Ruger concludes, "In general, the value of specific habits under a change of conditions depended directly on the presence of a general idea which would serve for their control." *(p. 18.)* He says further that

"Transfer was more effective in those cases where the formula or general rule was developed in the first few trials, and where the formation of perceptual motor habits had been controlled and interpenetrated by it from the start, than when the generalization had been arrived at after these had been set up." *(p. 88.)*

(c) Woodrow's experiment.[10] This experiment as well as the next one were conducted primarily for the purpose of comparing the relative amount of transfer as a result of different kinds of training of the subjects in the practice series. Consequently, in each experiment there are three groups instead of two,—one control group and two training groups. One of the training groups was trained according to the traditional method of practice—habit formation, and the other group was trained in another way as will be indicated below.

Woodrow's problem is to compare the results obtained by two methods of training in memorizing. One consists of unenlightened or rote drill (practice group), and the other involves conscious formulation of technique of procedure (training group). As a standard of comparison there was also a control group which did not engage in memorizing. All of these groups were given the preliminary and end tests as usual. In addition to these tests the practice group was given drill in memorizing "in a routine fashion without any explanation of principles, discussion of methods, or comparison of the methods to be used in the different kinds of problems." To the training group some practice was given in memorizing, but in addition there was conscious formulation, discussion, and comparison of different techniques of memorizing.

[10] The Effect of Type of Training Upon Transference. *Journal of Educational Psychology*, 18:159-172, March, 1927.

(For more detailed description of technique *see Chapter VII, p. 138ff.)*

The results of the experiment show conclusively that the group which was trained in mere routine fashion was inferior to that which was given the benefit of formulating generalization of techniques of memorizing. Says Woodrow, "A study of the entire column (of results) of differences between initial and final scores shows that the practice group sometimes improved more, and sometimes less, than the control group. In other words, the data indicate that the practice given this group sometimes helped, but in two cases interfered with performance on the final tests. In the case of all the end tests except one, however, the difference in improvement between the practice and control groups is small and statistically unreliable. . . . The training group, on the other hand, shows for every end test a decidedly greater improvement than either the practice or the control group."

The significance of the findings and their application to teaching procedure in school subjects is quite evident, as Woodrow points out. "While the investigation that has been described has taken the form of a laboratory experiment, it is hoped that it shows sufficient analogy to schoolroom situations to have a definite bearing upon education. For example, it might be found that the study of some particular subject, such as algebra, produces little improvement in ability to reason about problems in other subjects. According to the present results, however, such findings would tell little with respect to the possible value of the aforesaid subject as a medium for the giving of drill in the technique of reasoning, or of the results which could be attained by its study under a teacher

who so used it. Naturally, such a teacher would need to know both the proper technique of reasoning, and how to illustrate the use of the technique in many widely different fields. To determine the amount of transference of ability that did result from the study of a particular subject is one thing, to determine the amount of transference which might be secured from the study of the same subject is a different and far more difficult thing."

(d) Meredith's experiment.[11] This experiment is a corroboration of Woodrow's findings. It deals with the determination of the amount of transfer from the definition of scientific terms to the definition of ordinary words in daily use. Three equivalent groups were established on the basis of scores in intelligence tests and teachers' estimates. Group A was the control group, B the practice group, and C the training group. As in the experiment of Woodrow, all these three groups were given the preliminary and final tests. Group B was given training in defining scientific terms in mere routine fashion, that is, "without conscious ratification." On the other hand, the members of Group C "were trained in definition, the extent of training amounting to three periods of discussion of some ten minutes each, which included practice in defining and critical analysis of actual definitions. The training was thus not a simple, unitary process, but a combination of several activities involving the higher critical function of the mind." That is, in Group C, in addition to drill in defining scientific terms there was a critical analysis and evaluation of the features of a definition. In other words, there was a

[11] Consciousness of Method as a Means of Transfer of Training. *The Forum of Education*, 5:37-45, February, 1927.

process of reconstruction and refinement of definitions according to certain criteria such as:

(1) A definition must include everything that is included in the meaning of the word.

(2) It must exclude everything else.

(3) It must not be a mere repetition of the word to be defined.

(4) It must be in clear, simple, straight-forward language.

The results of Meredith's experiment supports Woodrow's findings. "B's average score in Test 1 is equal to A's, both being 29. Hence, no correction is needed here, and it may be taken that B's score in Test 2 without training would be the same as A's, viz., 32. Actually, it is 35, an increase of 3, which, it must be remembered, is an increase of errors and would seem to indicate not an improvement due to practice, but the reverse. However, when compared with the probable error of difference which is 1.9, that is, more than one-half, it is seen to have a reliability so low that nothing can be inferred beyond that the group shows no signs of benefiting, in the ability to define ordinary terms, from its practice in defining scientific terms.

With Group C it is otherwise.

A's average score in Test 1 is 29, C's is 31.

A's average score in Test 2 is 32. If C had not been trained, we may take that its score in Test 2 would have been $\frac{31 \times 32}{29} = 34$. Its actual score is 22, an improvement of 12. The P. E. difference is 1.5. Since the difference is eight times its probable error, the probability of its correctness is many thousand to one. We are accordingly justified in affirming that

Group C benefited in its training in defining scientific terms and carried this training over, or 'transferred' it to the definition of ordinary terms."

The difference between Thorndike's procedure and that of Woodrow, Meredith, and Judd is quite evident. Thorndike trained his subjects in routine fashion, that is, without conscious formulation of guiding principles. The results show very small transfer in most cases and interference in others. These findings are verified by Judd, Woodrow, and Meredith in the case of practice groups that were merely drilled in routine fashion. But besides this practice group, Judd, Woodrow, and Meredith had another group which, in addition to practice, was given training in conscious formulation of guiding principles or generalization (Judd), training in technique of memorizing (Woodrow), or of "critical analysis of the important features of a definition" (Meredith). The conclusion is inevitable that when an individual is trained in mere "routine fashion" or drill, he gets fixed and mechanical habit which does not transfer. On the other hand, when he is trained consciously to organize his knowledge or procedure in such a way that general principles are formulated, the result is not a mechanical habit but generalization—or adaptive and flexible form of behavior which by virtue of its flexibility transfers.

The final outcome that we are led to is that Thorndike did not get much transfer because the conditions favorable to transfer were not present. The next chapter will deal with detailed comparison of different methods of experimental procedure with the view of giving this claim further substantiation.

CHAPTER VII

CRITICAL EVALUATION OF EXPERIMENTAL PROCEDURE: COMPARISON OF TECHNIQUES OF PROCEDURE

WE have tried to point out in the last chapter that the reason why Thorndike obtained limited amount of transfer is that his experimental procedure was so arranged that conditions favorable to transfer were not present. Further to substantiate this claim, the writer presents several groups of experiments each of which bears upon the same or very closely similar problem. In this way it would be possible to check up more adequately and more fully the effect of method of experimental procedure and of other conditions affecting the experiments. We are therefore concerned in this chapter with summarizing several experiments under the following headings:

I. The development of observation.
II. The training of memory.
III. The development of reasoning ability.
IV. The development of neatness.
V. The effect of Latin upon English.

I. The development of observation. The problem of training visual apprehension has been dealt with by five different investigators at different times, namely, Aiken, Whipple, Foster, and Dallenbach in this country and Saxby in England. It is a problem of great importance to the educator, and the treatment it has received substantiates this claim.

In 1895, Miss Catherine Aiken of Stamport, Connecticut, published a book on Methods of Mind Training which is an account of certain exercises for the

purpose of mental training, particularly of training in the concentration of attention.[1] Her results can be best expressed by a quotation from Whipple. "The results cited in this book are so extraordinary as to challenge attention both from psychologists and educators, for if it be possible, by devoting ten or fifteen minutes daily to simple exercises, to accomplish the results which are claimed, it would appear to be incumbent upon all teachers to institute such exercises and to regard them as a very essential part of schoolroom training. If, on the other hand, Miss Aiken's results cannot be duplicated, it is equally important to establish this fact and then, if possible, to find the cause of the discrepancy."[2]

An example of such extraordinary result will be found in Miss Aiken's account *(pp. 32-33)*. One of the exercises is that of presenting to the class columns of figures which were repeated after a single glance and then erased. For instance:

54	16	48	32
100	800	1789	500
1483	1702	1452	1652
621	1815	1321	350
1635	1300	11	1400
476	600	751	290
1000	24	560	6000
27	13	1492	00
10			

"The purpose of the exercise was solely to arouse an eager attention which could be shared by each individual without regard to scholarship, to quicken the activities of the mind, to fix the attention, and help to

[1] Aiken, Catherine. *Methods of Mind Trainings Concentrated* Attention and Memory. New York, 1895, pp. 107.

[2] Whipple, G. M. The Effect of Practice Upon the Range of Visual Attention and Visual Apprehension. *Journal of Educational Psychology*, Vol. I, pp. 250-51, 1910.

form the habit of looking at things accurately and of holding them in the mind." *(p. 32.)* As there was no occasion for retaining the figures in the order of their arrangement in a single glance, it is surprising to us and no less to Miss Aiken that "after some days (no exact number of days given) had passed, I discovered my pupils could recall two or three columns of figures similar to the above (notice the fact that the columns recalled are not the same as those exposed for training) in their order without hesitation or error." *(p. 33.)*

The reason for this result, Miss Aiken ascribes to concentrated attention which is given at the time the impressions are received and to training in habits of mental associations. For example, a column of figures she had written "had conveyed to their minds, in a single glance, one or more facts of history. For example:

100 (B. C.) Birth of Julius Caesar.

1483 Birth of Raphael and Martin Luther; death of the little princes in the tower.

621 Mohammed's entry into Medina.

476 Downfall of the Roman Empire.

1000 Visit of the Norsemen to America.

800 Charlamagne crowned pope.

1702 Death of William of Orange. Accession of Queen Anne.

1815 Napoleon's escape from Elba; Waterloo; Wellington's victory.

1300 Pope Boniface VIII; Dante at Rome.

600 (B. C.) Buddhism introduced into India.

1321 Death of Dante.

751 Rome founded.

1492 Castile and Aragon united; Expulsion of the Moors; Columbus discovered America. *(pp. 33-34.)*

Several other examples are given and the results are no less amazing. These claims are not supported by statistical tables and graphs, and it is therefore entirely in order to subject them to a more accurate and precise determination of their validity. Consequently, Whipple, Foster, and Dallenbach in this country and Saxby in England, performed experiments on the same problem, although as we shall see the conditions are not quite the same.

The first of these investigations was made by Whipple [3] in the Cornell Psychological laboratory in an attempt to measure the extent, and to analyze the nature of improvement due to practice in visual apprehension. He had two sets of experiments. In the first set in which he tested the range of attention of six college students as subjects he had five-, six-, and seven-place series of isolated letters exposed with a tachistoscope for .08 of a second. His findings agree with those of others in that the average range of attention was between four and five impressions; that practice had a very slight effect which may be explained in terms of habituation to the experimental conditions and of the development of tricks and schemes of grouping; and that the range of attention itself is not affected by practice. In the second set of experiments in which three adults (two professors of psychology and one instructor with a small amount of psychological training) acted as subjects, he dealt with visual apprehension and had groups of dots, pictures, drawings, nonsense syllables, and stanzas of poetry exposed for three seconds with a tachistoscope, and a collection of ten objects exposed for six seconds. The findings agreed with those in

[3] *Ibid. .pp.* 249-62.

the first set in that when adaptation and assimilative devices were eliminated the effect of practice was negligible. An analysis of the results showed that performance was due to "native capacity, degree of attention, specific capacity for given types of material, ease of assimilation of the material shown, 'obstruction' or distraction, ideational type, voluntary restriction of observation and grouping." *(p. 250.)*

The second experiment from the Cornell Psychological laboratory was performed by Foster.[4] His object was "to measure the observers' initial and final ability to represent to themselves in image, impressions recently given in sensation, . . . and to discover the factors or processes concerned in observation and reproduction, together with their relative importance." His subjects were all trained psychologists, and he followed essentially the same procedure as Professor Whipple and as recommended by Miss Aiken. His findings agree very closely with those of Professor Whipple. In his own words, "We have found that practice such as ours does increase ability to reproduce our sort of material. We see, however, that this increased ability is dependent upon particular material, time, instructions, and other conditions of the experiment, upon familiarity with these conditions, and upon confidence based on the familiarity. Practice, in other words, is specific. Practice with one set of conditions is valuable in a new set, only in proportion as the second set of conditions contain identical ability-conditioning factors." *(p. 21.)*

Both Whipple and Foster realized the limitations of their studies and qualified their conclusions. Whipple

[4] Foster, W. S. The Effect of Practice Upon Visualizing and Upon the Reproduction of Visual Impressions. *Journal of Educational Psychology*, 2:11-22, 1902.

says, *(p. 251)*, "It may be admitted at the outset that the negative outcome of these experiments is not entirely conclusive; it may be objected that practice was not sufficiently long; it may be objected that our observers were adults, and that the outcome would have been essentially modified had our tests been applied to children." Accordingly, it was his intention "to withhold publication until the tests could be repeated with school children. As circumstances have conspired to render this impossible, the results are now published with the hope that other investigators may undertake similar tests with children." *(p. 249.)* Similarly Foster concluded his study in the following words. "That training in these experiments has made the O's noticeably better observers or memorizers in general, or given them any habits of observing closely or reporting correctly, or furnished any ability to meet better any situations generally met with, neither we nor any of the observers themselves believe. It seems, therefore, as if the value of formal training of our kind had been greatly overestimated. However, our experiments were made upon adults who were already trained in habits of attentive observation, and we have no right or wish to extend our conclusions in a wholesale fashion. It may be that immature or untrained persons practiced in visual reproduction might possess a general value that was not discovered under our conditions." *(p. 21.)*

With the above limitations in mind, Dallenbach [5] repeated the experiment with children, both normal and feeble-minded. The experiment with normal chil-

[5] Dallenbach, K. M. The Effect of Practice Upon Visual Apprehension in School Children. *Journal of Educational Psychology*, 5:321-34; 387-404, 1914. Also The Effect of Practice Upon Visual Apprehension in the Feeble-Minded *Journal of Educational Psychology*, 10:61-82, 1919.

dren was reported in 1914 and that with feeble-minded children in 1919. Since the latter experiment verifies the former it suffices for our purpose to describe the 1914 investigation. With a period of seventeen weeks daily ten-minute exercises in the rapid observation and reproduction of various visual materials, letters, digits, words, geometrical figures, etc., were given to twenty-nine second-grade public school pupils (in class) of both sexes. The experiment was very carefully conducted and controlled and therefore warrant the following conclusions: 'We conceive the moral of this study to be that, while the mental processes of children are alike in kind to those of adults, their lesser maturity alters appreciably the outcome of experiments dealing with the effects of prolonged drill in the exercise of mental activity. The careful, though less extended experiments of Whipple and Foster showed no appreciable effects of drill upon adults save those rather temporary effects explicable as adaptation to experimental conditions and to the special task, that is, as the development of special devices for facilitating the exercise of already matured capacities. Our more lengthy experiments with children, however, have not only showed more decided practice effects, but have also rendered it at least quite possible, if not practically certain, that these practice-effects have brought about a permanent modification in the mental traits exercised, and what is more a modification that certainly seems to have made itself felt in a number of ways outside the special tests we made (as in improvement in school work and increased efficiency long afterward in supplementary tests of observation and report). In this respect our experiment, therefore, may be regarded as contribut-

ing some evidence in favor of a restricted belief in formal discipline." *(p. 403-4.)*

It will be important to inquire at this point why there is a discrepancy between Miss Aiken's and Dallenbach's results on the one hand and Whipple's and Foster's results on the other. Two factors have already been mentioned by Whipple, namely, (1) the length of practice and (2) the age and experience of the subjects. As for the first, there is no doubt that the amount of transfer depends to a large extent upon the amount of practice. This is obvious in the case of school studies. The longer you study mathematics, for example, the more mathematical knowledge and skill you possess, and hence you have more of each to transfer. It is, of course, quite possible that the more one specializes in mathematics the less capable he is of transferring his knowledge to other fields. Interference in this case, however, is due to the fact that one has tended to specialize in one field and to so exclude from consideration other fields of knowledge. The second cause of discrepancy, namely, that of difference in age and training of subjects, is no less obvious. The psychologists and adults have had training in observation. Psychologists, furthermore, have familiarity with experimental conditions, attention to details, and tricks of grouping. The amount of improvement due to practice would then be negligible, and that therefore Miss Aiken's conclusions may be entirely valid. In her conclusion, Miss Aiken ascribes her results to "power of an individual attention, concentrated upon that which is highest, noblest, and best." Of course, it ought also to be admitted that training in attention is not exclusive but inclusive of the specific conditioning factors that Whipple enumerates, namely, "native capacity, degree of attention,

specific capacity for given types of material, ease of assimilation of the material shown, obstruction; or distraction, ideational types, voluntary restriction or observation, and grouping." It was cited above, that the children had associated certain events to the column of figures given. This certainly can be classified as a method comparable to Whipple's "tricks and schemes of grouping" or to Foster's "ability-conditioning factors."

In addition to these two factors, I might add, the personality of the teacher, the kind of exercises, and the general conditions surrounding the experiments. In Whipple's and Foster's experiments we have a laboratory situation which is quite different from the schoolroom. It might be that Miss Aiken's results are due to her dynamic personality. We cannot as yet discount the effect of the teacher upon school achievement, and if that is the case, so long as the personality of the teacher is not controlled, we cannot be sure of our comparative results.

We come next to an English experiment which seems to approximate more than Whipple's and Foster's and perhaps Dallenbach's, and the experiment of Miss Aiken. Like the experiments after Miss Aiken, this one is performed for the purpose of verifying the results of Miss Aiken. Miss Saxby of England followed the same procedure and gave similar exercises to children of approximaely the same age during a period of twelve weeks with regular practice of fifteen minutes a day for four days a week. She performed the experiments in four different elementary schools (where special training was given) and repeated them in four others (without special training). She gives no data for her results but declares that "the effect produced by the special exercises was almost nil."

She even goes so far as to say that "As a suggestive force the effect of the exercises is negative rather than positive," but says that if there was any improvement in the trained classes, "it was in the main due to the development of a desire to become more observant."

There are, however, certain differences between Miss Aiken's experiment and Miss Saxby's. First of all, we notice that Miss Saxby has three different materials, namely, (1) memory drawing of well-known objects, (2) reproduction of a story read to the class once only, and (3) reproduction of a list of ten numbers shown to the class for thirty seconds. Miss Aiken has a greater variety of exercises,—in fact, she has ten of them, and if such is the case, the practice is not only more extensive in time but also more varied. It has been pointed out by Whipple that the material used, and certainly the variety of it is an important factor in training for observation. Of course, it is almost impossible to agree entirely with Miss Aiken's claims, nevertheless we cannot fail to accept the fact that there was improvement. Dallenbach's experiments showed this fact, and again, we might ask Miss Saxby why there is a negative effect.

We may also criticize Miss Saxby's investigation in that she evidently measured the more permanent effects of observation, whereas Miss Aiken noted her results after the exercise. Which is the better measure of the effect of training, is another question. She says in summarizing her results, "Under suitable conditions a well-worked and effective desire can be developed in this way, but the improvement produced is not in general permanent. In test four (which was given in four months after training) the difference between the trained and the non-trained is no longer significant for the class as a whole." It is evident

that there was a difference due to practice at the end of the last test, but that this difference faded in four months' time. This is quite contrary to Dallenbach's findings in which he finds that the effect of practice was evident after the fifty-eighth week. It is here noted that Dallenbach had forty different exercises as compared with three of Miss Saxby, and the training extended to seventeen weeks of five days a week, ten units each, as compared with twelve weeks, four days a week, and fifteen units a day. The practice covered a larger period of time and included more varied material.

It is also quite possible that the personality of the teacher has its effect. Add to this the experimental condition and you will have two different situations. Miss Aiken conducted her experiment in her own class, but in all the other experiments including that of Miss Saxby, the experimental conditions were quite artificial. Miss Aiken made the situation natural by making the exercises a part of the recitation. It is not claimed here that Miss Aiken's results are to be accepted without reservation. But, still we cannot help but give her some credit for what she claims. As long as we regard the personality of the teacher and her method of presenting subject matter as important factors in the progress of learning, we are inclined to venture the hypothesis that a considerable portion of the difference between Whipple's and Foster's experiments on the one hand and that of Miss Aiken's on the other is due to these factors.

II. The training of memory. The first experimental investigation to determine the effect of practice upon the so-called faculty of memory was made by James.[6] He learned 158 lines of Victor Hugo's

[6] *Principles of Psychology.* Volume I, pp. 666-67.

Satyr, and then practiced in memorizing the entire first book, *Paradise Lost* for thirty-eight days. After the training he went back to Victor Hugo's poem and found that 158 additional lines took him 151½ minutes whereas before training the same number of lines took him only 131 5/6 minutes. In other words, he obtained "just the opposite result from that which the popular view would lead one to expect." He admits, however, that he was "perceptibly fagged with other work at the time of the second batch of Victor Hugo."

Consequently, he persuaded four other persons to repeat the experiment. Burnham, Brown, Baldwin, and Pease tried the experiment but the results were not consistent. Two of these persons found very slight improvement while the other two found degeneration after practice. The difference in each case, however, is very slight.

In conclusion James says that "all improvement of memory consists, then, in the improvement of one's habitual method of recording facts." *(p. 667.)*

Peterson [7] repeated the above experiment with nine subjects. The results as the author points out indicates that there "was certainly a large transfer of training here." He points out, however, that transfer was due to "getting practice in verbatim memorizing," 'memorizing by whole rather than by parts," "reading rapidly after the sense has been grasped, skeletonizing the thought," etc. In other words, the results verified James' hypothesis that training is due to improvement in method of memorizing.

The first serious and elaborate experimental investigation to determine whether "there is a general mem-

[7] Note on a Retrial of Professor James' Experiment in Memory Training. *Psychological Review,* 19:491-92, 1912.

ory function which can be perfected upon any material involving the use of memory" or whether we "must posit related or unrelated special memories" was undertaken in the Zurich Psychological Laboratory between the period from November, 1902 to August, 1903, by Ebert and Meumann.[8]

The following experiment was carried through with six observers. First, in a series of preliminary experiments the existing state of the observer's memory was determined, that is, a cross-section was made through all of his special memories. They first of all tested immediate retention by determining the compass of retention of numbers, letters, words, nonsense syllables, stanzas of poetry, and selections of prose. Then they tested permanent retention in the genuine learning of nonsense syllables, poetry, and prose, and finally a special investigation of visual memory was made. After the cheif sorts of memory in unpracticed individuals had thus been determined quantitatively, the drill experiments began. Only a single type of memory was trained,—the mechanical memorization of nonsense syllables,—and the training was continued through thirty-six consecutive days. At the end of this period, they again made a cross-section through all of the varieties of memory present in the individual in order to discover whether these other memories had profited from the training. Then they again trained certain of the observers for eighteen, others for thirty-six days, in the mechanical retention of nonsense syllables; and then once more a quantitative determination of the special memories was made.

Now these experiments show that all of the sorts of memories were considerably improved by mere drill in the learning

[8] For a brief description see Meumann, *The Psychology of Learning*. Appleton's, 1913, pp. 353-54.

of nonsense syllables. Even a function which is so different from genuine memorization as the immediate retention of non-significant impressions had been considerably strengthened. Purely visual memory had been improved by the learning of nonsense syllables, as had also the learning of abstract prose selections,—a function which is utterly different from the practiced function; and the memorizing of poetry had also been improved. This, to be sure, establishes only the fact that there is such a thing as a general memory training, and that our whole memory is improved when we train it with any sort of material.[9]

Serious objections, however, may be raised in connection with these experiments, the most important of which is that the absence of a control group made it impossible to determine how much of the gain is due to practice and how much is due to indirect training.

It appears then that Meumann and Ebert's experiment is quite inconclusive. As a result of these apparent limitations of Meumann and Ebert's methods, and hence, the inconclusiveness of their results and conclusions, two identical experiments have been made in America.

The first of these is that by W. F. Dearborn which was read before a meeting of the American Psychological Association in 1908, and the abstract of which was reported in the *Psychological Bulletin,* Vol. 6, 1909, p. 44. (It is unfortunate that such valuable material should not have been published in full. As it is, we have no data and have to rely upon the words of the author. This is particularly significant in view of the fact that Radossawljewitsch [10] repeated the experiment of Ebert and Meumann and found considerable transfer).

Acting on the hypothesis that "The possibility of improvement through the repetition of the test series

[9] Meumann. *The Psychology of Learning.* p. 354.
[10] *American Journal of Psychology.* 19:274, 1908.

themselves may in part account for the unusually large amount of the apparent influence of the special practice," Dearborn repeated the experiment of Ebert and Meumann under similar conditions except that a control group was provided in order to measure the effect of the special practice. The "results seem to render unnecessary the hypothesis proposed by Ebert and Meumann to account for the large extent of the general influence of special practice, which their experiments seem to indicate." This conclusion is evident from the fact that "the results indicate that a considerable part of the improvement found must be attributed to direct practice in the test series, and not to any 'spread' of improvement from the practice series proper. There is further, at times, lack of correlation between the amount of improvement made in the practice and that made in the test series. . . . This again indicates the presence of direct practice in the test series."

H. B. Reed [11] of the University of Idaho repeated Ebert and Meumann's experiment with great care. The experiment was so controlled that "not only did the subjects spend more time in practice and learn a greater quantity of material but they also attained a greater amount of improvement both in learning and re-learning than did the subjects of Ebert and Meumann in their first practice period." If that is the case, as stated by Reed, "Other things being equal, the subjects of the test experiment should have shown more spread of improvement than those of Ebert and Meumann, but the former, unlike the latter, instead of showing that improvement in one function raises the efficiency of every other function to a large extent,

[11] A Repetition of Ebert and Meumann's Experiment on Memory Trainnig. *Journal of Experimental Psychology*, 2:315-46, 1917.

showed that it principally raises the efficiency of the one specially trained and that of other special functions to a small extent, provided they are similar." *(p. 334.)*

Woodrow's experiment[12]: The one conclusion which we can make from the conflicting results of the above experiments is that the amount of transfer is very limited. Woodrow's experiment, however, is at variance with these findings. As we have already pointed out in an earlier analysis of the experiment, he attempted to determine the relative effects of two different methods of memorizing upon the amount of transfer. As we have seen, there were three groups, the customary control group, a practice group, and a training group. The practice group was given training in memorizing which consisted of unenlightened drill. This group is equivalent to the experimental or training groups of the experiments which we have already described. The training group was trained in a different way so that, instead of mere drill in memorizing, there was a conscious formulation of techniques of procedure in memorizing. Several devices were taught to the members of the training group which were discussed in class. They include:

(1) Learning by wholes.
(2) Use of active self-testing.
(3) Use of rythm and grouping.
(4) Attention to meaning and the advantage of picturing, or, depending upon the individual, otherwise symbolizing the meaning.
(5) Mental alertness and concentration.
(6) Use of secondary associations.

[12] The Effect of the Type of Training Upon Transference. *Journal of Educational Psychology*, 18:159-72, March, 1927.

The program of practice periods was as shown in Table XII and the results are noted in Table XIII.

TABLE XII

PROGRAM OF PRACTICE PERIODS
(From Woodrow, Table II, p. 166)

Period	Practice Group	Training Group
I	20 minutes memorizing poetry	7 minutes listening to exposition of rules 13 minutes memorizing poetry
II	25 minutes memorizing poetry	7 minutes listening to exposition of rules 18 minutes memorizing poetry
III	28 minutes memorizing nonsense syllables	28 minutes listening to exposition and illustration of rules
IV	20 minutes memorizing nonsense syllables	5 minutes listening to review of preceding period 15 minutes memorizing nonsense syllables
V	19 minutes memorizing nonsense syllables	9 minutes attending to blackboard talk on meaning and secondary associations 10 minutes memorizing non sense syllables
VI	25 minutes memorizing poetry	25 minutes memorizing poetry
VII	20 minutes memorizing poetry	20 minutes memorizing poetry
VIII	20 minutes memorizing nonsense syllables	20 minutes listening to review of methods and the situations in which to use them
Total Time	177 minutes	177 minutes

Table XIII speaks for itself. It is evident, as Woodrow points out, that the "practice group sometimes improved more and sometimes less, than the control group. In other words, the data indicate that the practice given the group sometimes helped, but in two cases interfered with performance on the final tests.

In the case of all the end-tests except one, however, the difference in improvement between the practice and control group is small and statistically unreliable. . . . The training group, on the other hand, shows for every end test a decidedly greater improvement than either the practice or the control group."

TABLE XIII

GAINS, IN END TESTS, OF THE PRACTICE AND TRAINING GROUPS, AFTER SUBTRACTION OF GAINS OF THE CONTROL GROUP; AND GAINS OF THE TRAINING GROUP AFTER SUBTRACTION OF GAINS OF THE PRACTICE GROUP

(Woodrow, Table IV, p. 170)

End tests	Practice gain minus control			Training gain minus control			Training gain minus practice		
	Difference	P. E.	Dif. P. E.	Difference	P. E.	Dif. P. E.	Difference	P. E.	Dif. P. E.
Poetry	+ 6	±21	0.3	+115	±19	6.1	109	±23	4.7
Prose	—16	±21	0.8	+187	±26	7.5	203	±28	7.3
Facts	+ 0.3	± 1.9	0.2	+ 11.7	± 1.6	7.2	11.2	± 2.1	5.3
Dates	+ 0.5	± 0.4	1.3	+ 35	± 0.4	8.8	+ 3.0	± 0.5	6.0
Vocabulary	+ 0.6	± 0.6	1.0	+ 7.6	± 0.7	10.9	+ 7.0	± 0.8	8.8
Span	— 0.8	± 0.1	8.0	+ 0.9	± 0.1	9.0	+ 1.7	± 0.1	17.0

We have here a clear and unmistakable evidence of the role played by conscious generalization of method of procedures as against mere routine in memorizing. The reader should note that in the case of the training group the amount of time given to discussion and listening to exposition of principles is almost as much as the time given to actual practice in memorizing—(101 minutes was given to memorizing and 76 minutes to discussion and generalization of rules and principles of better techniques of memorizing). The practice group spent the 177 minutes in actual memorizing and, consequently, had more practice.

We are therefore justified in concluding that the amount of transfer in memory from one material to another depends a great deal upon the method used in the practice series. Where it is unintelligent routine, we get very little or no transfer, but where conscious formulation of principles or generalization of techniques of memorizing is made, there is great amount of transfer.

III. Mathematics and Reasoning. It is generally claimed that mathematics, especially geometry, develops reasoning power better than any other subject in the curriculum with the exception, possibly, of Latin. The first quantitative investigation to determine the validity of this claim was made by F. C. Lewis in Dartmouth College.[13] The effect of the results and conclusions drawn from the experiment has been felt since then to the present. It has been criticized from all angles, statistically, theoretically, and otherwise.

The object of the experiment is twofold. First, to determine whether or not the good mathematical reasoner is a good practical reasoner, and second, to determine whether or not the good mathematical reasoner is a good reasoner in law. In other words, he set to find out "if it is true that the good mathematical reasoner is the good general reasoner."

To solve the first problem, he devised two tests, one test in geometrical reasoning consisting of originals in geometry, and the other a set of three exercises in practical reasoning, such as 'Give all the reasons you can why a high-school education is a good thing,' 'Why should the town rather than the parents pay for the education of its children,' and 'Which is of more value,

[13] *School Review. April,* 1905, pp. 281-92.

physical or mental training?' 'Give all reasons you can for the position you take.'

"These tests were submitted to twenty-four different groups of high-school pupils. The students of each group belonged to the same class and were on an equality with respect to mathematical preparation. Each group took both tests." Papers in both tests were carefully graded and arranged, first, according to their ranking in mathematical reasoning, and second, according to their ranking in practical reasoning.

It is clear, as indicated by Lewis' results, that there is a conspicuous lack of correspondence between the ranks in mathematical reasoning and practical reasoning.

The second experiment deals with a comparison of ability to reason in mathematics and ability to reason in law. He examined the records of Dartmouth students who had taken mathematics and "certain law courses which required a good deal of reasoning." The records for ten different classes were examined and tables were formed as in the previous test. "Fifty percent of the best students in law were conspicuous for their poor showing in mathematics; and forty-two percent of those poorest in law stood at the head of the series in mathematics." His final conclusion is, "These tests are surely convincing of one thing, viz., that students able in mathematical reasoning are not even generally able in practical reasoning and law."

M. H. Van Fleet [14] made an investigation "to find if reasoning developed in geometry carries over into general reasoning ability. She had five classes, one in each of Geometry, French, English, Latin, and Algebra. She devised two sets of general reasoning tests, one of which was given at the beginning of the

[14] Unpublished Thesis, Purdue University, 1924.

semester, and the other at the end of the semester. She arranged to have twelve pairs, one pair consisting of pupils who were taking geometry and the other of pupils taking the other subjects. Pairing was made according to age and initial score in the reasoning test. When results in scores in the reasoning tests were compared, it was found that those who studied geometry had no advantage over those that did not study geometry.

The result is as follows:

	Reasoning Test No. 1 mean	Reasoning Test No. 2 mean	Difference
Geometry	30.75	42.25	11.50
Control	30.67	41.08	11.41
		Superiority of Geometry	.09

Thus, it is evident that the subjects that studied geometry for a semester did not have any advantage over those that did not so far as general reasoning is concerned.

The next experiment was made by Winch.[15] It deals with the problem, "Does improvement in Arithmetical Problematic Reasoning involve improvement in logical reasoning which is not arithmetical?" The problem is similar to that raised by Lewis and Van Fleet.

"The experiment was undertaken with Standards VIb and V, consisting of fifty-eight girls of an average age of twelve years and three months." Preliminary tests in logical reasoning were given to the subjects to determine their capacity in logical and arithmetical reasoning. On the basis of scores in logical reasoning and of age "two equal, parallel, and highly correlated groups were obtained. One of these groups was

[15] The Transfer of Improvement in Reasoning in School Children. *British Journal of Psychology*, 13:370-81, 1923.

trained specially in problematic arithmetic; the other was taught reading, geography, and dictation. After the practice which lasted ten weeks, the final tests were administered. The results show a decided advantage of the practiced group over the unpracticed group."

TABLE XIV

SHOWING THE RESULTS IN LOGICAL REASONING OF THE TWO GROUPS COMPARED. *(Condensed from Winch's Table I, p. 380)*

	Average preliminary score	Average final score	Gain	Percent gain
Practiced group....	35.0	49.5	14.5	41.4
Unpracticed group..	34.8	38.8	4.0	11.5
Superiority of practiced group				29.9

Only two girls in the practiced group have failed in the final tests to surpass those in the non-practiced group with whom they were originally paired." *(See p. 380.)*

A table is also given to show the results in Problematic Arithmetic of the two groups compared. Winch summarizes the results as follows: "A differential improvement of 24.4 on sixteen marks in favor of the group practiced in Problematic Arithmetic is accompanied by a differential improvement of 10.5 on thirty-five marks in Logical Reasoning. In other words, a differential improvement of about 150 percent in Problematic Arithmetic is accompanied by a differential improvement of about 30 percent in Logical Reasoning." *(p. 381.)*

The question at once arises, 'Why the difference between Winch's results and those of Lewis and Van Fleet?' Lewis found no correlation between mathematical reasoning and practical reasoning and Van Fleet found that training in reasoning in geometry did not transfer to practical reasoning. We have thus been shown the lack of correlation in the one case and lack of transfer in the other case.

In every psychological experiment the method is a part of the result since the processes involved are so complex and varying. Therefore the first question that can be pertinently raised is, Has there been a difference in the method of procedure? In general, there is no significant difference between the procedure of Lewis, Van Fleet, and Winch. Lewis, of course, took for granted that geometry trained in reasoning in geometry and was only interested in finding out whether one's ability to reason in geometry is accompanied by a corresponding ability to reason practically. He did not measure nor attempt to measure whether or not there was transfer of improvement from training in reasoning on things geometrical to cases non-geometrical. But, everything being equal, if it is found that those who are bright in geometry are bright in reasoning about practical things, we might be justified in claiming that geometry trains in general reasoning. And in so far as there is an almost inverse relation of the two abilities, we are warranted in concluding that there was no transfer; indeed, there is evidence of interference.

But Van Fleet's procedure and that of Winch's are essentially the same. Each had two groups of pupils, one a control group and the other a practice group. These groups were divided on the basis of initial score

in the Logical Reasoning test and on the basis of age. The experimental group in each case was practiced in mathematical reasoning, and the control group in other subjects. The only difference is that of subject matter. Van Fleet had geometry and Winch had arithmetic. But both are mathematics and, furthermore, if there is any favor it is on the side of Van Fleet, since geometry is specially taught to develop logical reasoning. Another possibility is in the nature of the reasoning tests. The test series are different in content but both test logical reasoning. We can say that if there was a difference it did not amount to any significant figure. A third explanation might be that of difference in the amount of practice. Van Fleet had the whole semester and Winch had ten weeks. Again, if there is any favor it is on the side of Van Fleet.

A fourth explanation might be in the difference in the character and amount of improvement in the practiced function. Van Fleet does not give any figure, but Winch gives an evidence of 150 percent improvement in arithmetical reasoning. Since this is a very important consideration, we rather suspect that the difference lies in this matter. The amount of transfer depends to a very great extent upon the amount of training—that is, the amount that can be transferred. If there is only an improvement of 10 percent in the trained function, we cannot expect a transfer to amount to more than 10 percent. Furthermore, the kind of improvement in the trained function makes a lot of difference. This consideration leads one to inquire what is mathematical reasoning. And, is it really developed by practice in geometry, arithmetic, algebra, etc.?

This raised a fifth problem as a possible source of discrepancy of results. Is there a difference in the teaching procedure? The writer believes that there is. It will be more evident in our discussion of the next experiment. Neither Van Fleet nor Lewis give us an explanation of the method in which geometry was taught to their subjects. Since there was no explanation, we are justified in assuming that geometry in both cases was taught in the traditional way. The question arises, Does geometry taught by the ordinary method develop reasoning in mathematics in general and geometry in particular? Or, is the resulting knowledge merely formal, verbal, and routine? We suspect that it is merely formal. It consists in mere juggling of figures, memorizing of theorems and proofs.

The question comes, What method was used in teaching arithmetical reasoning to Winch's subjects? And what is the difference between it and the traditional method? The author of the experiment gives samples as to the procedure in teaching the pupils the way to solve the problems in the practiced group. It is noticeable throughout that "principles involving the solution (of problems) have been taught and careful statements have been required as to procedure." As Winch points out, "Mere juggling of figures with numbers until a correct solution appears, more or less by accident, is not problematic arithmetic and will have little if any 'transfer value' either to similar arithmetical problems or to any other subject." The teacher in the case of Winch's experiment gives the problem to the pupils to solve. Upon arriving at a correct or incorrect solution, the teacher asks them why they did what they did. If a statement is not so clear, she requires a better one until the statement is

made as clear as is desired. The problems are developed inductively, and a generalization which is a statement of the general principle involved in the solution of the problem is formulated. After the principle has been arrived at, several examples are given to test the pupil's ability to apply the principle obtained. Thus, by question and answer development, generalization, and application, the pupils are led to think rather than merely solve the problems.

What do we have, by contrast, in the traditional method? Whether in arithmetic or in geometry the work is largely formal. The teacher assigns problems and pupils write the correct solution on the board. If the answer is correct, it is assumed that the process of thinking has been gone through. Answer-getting is the aim and the end of the process. Here lies the difference between Winch's method and the traditional method.

The next experiment brings out more clearly the difference between the traditional method of teaching mathematics and that which develops thinking. Miss Elsie Parker Johnson of Oak Park High School, Oak Park, Illinois, has contributed a splendid piece of work to the solution of the problem of transfer.[16] Like Van Fleet and Lewis, the subject involved is geometry, and the problem is this: "Can pupils of geometry be taught to prove theorems more economically and effectively when trained to use consciously a technique of logical thinking; and furthermore, does such training, more than the usual method increase the pupils' ability to analyze and see relationships in other non-geometrical situations?"

She had two groups divided on the basis of score in the Chicago Group Intelligence Test. The control

[16] Mathematics Teacher.

group had an average score of 51.3 while the experimental group had only 47.1. Both groups took geometry, but the experimental group was trained to use consciously a technique of logical thinking. The control group was taught in the ordinary way. The method of teaching the experimental group consists in leading the pupils to sense the real difficulty in the problem, to suggest as many possible solutions, to test out the suggestions and then to observe and experiment on the basis of the answer arrived at to determine if it can be applied to the solution of similar problems.

The results, as follows, are conspicuous in the superiority of the experimental group which started out as an inferior group as regards I. Q. At the conclusion of the training an original exercise was given to each group and a record was kept of the time each individual completed the solution of the problem.

(1) The members of the control group gave up trying sooner than the members of the experimental group — twice as many quit before the end of the time allowed. In one other problem, three times as many of the control group quit before the end of the time allowed. Thus, we see the development of persistence on the part of those that have been specially trained.

(2) The experimental group found four methods of solving the problem, and the control group only two.

(3) The Monroe Silent Reading Test which is a fairly good test of ability to reason along lines other than geometrical was administered before and after the training. In spite of the fact that the control group had a higher average than the experimental

group to start with, the experimental group surpassed the control group after the training.

(4) The final examination grades showed that the median for the control group was 70 and that of the experimental group, 75.

To check up the result, the experiment was repeated. There were 25 for the control group and 26 for the experimental group instead of 25 and 27 as in the first experiment. The average I. Q. of the control group was 109.8 and that of the experimental group was 107.7 (according to Terman Group Test of Mental Ability). The range of I. Q. for control group was from 90 to 127, and for the experimental group, 89 to 126. According to the Otis Higher examination the median I. Q. of the experimental group was 121.5 as compared with 134 of the control group. The groups were balanced as to age and sex.

The Burt Reasoning Test Form A as arranged by Miss Bruene in her Master's Thesis (1920) in the University of Chicago was administered to both groups before and after the training.

	Before Training		After Training	
	Control Group	Experimental Group	Control Group	Experimental Group
average	8.1	8	8	8.1
mode	9	7	8	9.0

On original theorems in geometry given before and after training, while the classes had the same number of correct proofs on the problem given before the training, after the training the experimental group had 1 1/3 as many correct proofs as the control group. If the proofs which were on the right track but not complete, were counted also, the ratio was 21 to 12 in favor of the experimental group. As in the previous experiment, the experimental group exhibited more

perseverance in endeavoring to find proof. The control group found only one method while the experimental group found three methods of proof.

In conclusion, Miss Johnson believes "that those data would seem to offer conclusive evidence, in so far as one experiment can be considered to do so, that when pupils are taught to use, consciously, a technique of logical thinking, they try more varied methods of attack, reject more erroneous suggestions more readily, and without becoming discouraged maintain an attitude of suspended judgment until the method has been shown to be correct. Furthermore, the results in tests of reasoning other than geometrical "would seem to indicate that such training in logical thinking with the materials of geometry tends to carry over these methods of attack and these attitudes to other problem situations not concerned with geometry." *(p. 200-1.)*

The conclusion we have come to in our discussion of the above four experiments are quite clear-cut and definite.

(1) To the question, 'Does training in reasoning in mathematics as ordinarily taught carry over to logical reasoning in general,' the answer is negative.

(2) But to the question, 'Can mathematics be so taught as to develop thinking which would carry over to things non-mathematical,' the answer is decidedly affirmative.

(3) Transfer takes place or not according to the method of presentation and the method of learning that the subjects undergo.

IV. Experiments in transfer of neatness. The effect of method of teaching upon the presence or absence and degree of transfer is most clearly demon-

strated by two experiments, the first by Bagley and Squire, and the second by Ruediger.

Under the direction of Professor W. C. Bagley, Dr. Carrie R. Squire conducted a series of experiments in the intermediate grades at the Montana State Normal College "to determine whether the habit of producing neat papers in arithmetic will function with reference to neat written work in other studies." No data are given, but Dr. Bagley says that "The results are almost startling in their failure to show the slightest improvement in language and spelling papers, although the improvement in the arithmetic papers was noticeable from the very first." [17]

Dr. Bagley concludes that neatness as a mere habit does not transfer. It has to be made a conscious ideal in order for it to spread to other situations which are different.

To test out this hypothesis, W. C. Ruediger [18] repeated the experiment with certain changes as to method. The problem of this experiment is different from that of Bagley and Squire's. Bagley and Squire tried to find out if habits of neatness in one subject function with reference to written work in other studies. On the other hand, Ruediger raised the question, "Does the ideal of neatness, brought out in connection with, and applied in, one school subject function in other school subjects?"

Besides training the pupils in the habit of neatness in written work, neatness as an ideal was emphasized. The teacher talked frequently with the class on the importance of neatness in dress, business, in the home, etc., except that discussion of neatness in other sub-

[17] *Educative Process.* p. 208.

[18] "Improvement of Mental Function Through Ideals." *Educational Review.* 36:364-71.

jects was carefully avoided. Three classes of seventh-grade pupils, one in New York, another in Dillon, and a third in Washington, were used as subjects. The ideal of neatness was emphasized in different subjects, such as geography and arithmetic. One or more papers were collected a week in three or more subjects, such as language (grammar), arithmetic, geography, and history—one of which is the basis of the experiment. The experiment lasted for three months in each school.

The results are clearly at variance with that obtained by Bagley and Squire. Ruediger states the findings as follows. "Evidently neatness made conscious as an ideal or aim in connection with only one school subject does function in other subjects." [89]

Evidence of transfer of neatness to general appearance, the care of the desks, etc., were also noticed. Thus a teacher recorded, "There has been an improvement, I believe, in the personal appearance of T. B., R. W., and G. M. The desks of J. F., L. R., G. M., and R. W. look better." *(p. 370.)*

V. The effect of Latin upon English. Most of the investigations reported here deal with certain problems raised by the American Classical League. They are, therefore, a part of a general program which deals with the validation of objectives of classical studies. The other experiments were either suggested by the League or were attempts to verify the findings of previous investigations along the same or similar lines.

Professor Thorndike carried a series of investigations dealing with the influence of first-year Latin

[89] *Ibid.* p. 369.

upon (1) range in English vocabulary,[20] and (2) ability to read English.[21]

The first one of these investigations was made in the school year 1921-22 in the first year of fifty-six high schools. The Thorndike *Test of Word Knowledge* (Form A) was given to all the pupils to determine their range of vocabulary. On the basis of scores in the test two equivalent groups, one made of Latin students and the other of non-Latin students were established. At the middle and end of the school year, Forms B and C were given to the groups to determine if there was any advantage due to the study of Latin. The results in both tests are consistent, and show that "The Latins thus make in general over one and one-half times the gain which the non-Latins of equal initial scores make."

The second investigation deals with the influence of first-year Latin upon the ability to read English. (The ability to read English is measured by the Thorndike-McCall *Reading Scale*). On the basis of scores in the scale two equivalent groups were created, one of Latins and the other of non-Latins. The result of the investigation is difficult to interpret as there was more gain at the end of the first half year than at the end of the year, that is, "the superior gain of the Latins for the whole year is found to be 1.81, and for the first half year to be 1.95." As Thorndike rightly says in this connection, "it thus appears that whatever caused the superior gains of the Latins was a feature of the first half year." If we assume as Thorndike says, that the study of Latin in Grade IX excels the other studies which were taken in its stead in improving

[20] *School and Society.* 17:82-84, January 20, 1923.
[21] *School and Society.* 17:165-68, February 10, 1923.

these pupils' abilities in reading, it is "hard to find adequate reasons why the second half year of the study of Latin should have had zero effect." If, on the other hand, we assume that the second half year had no effect, we are bound to expect that the first half year had no effect also. With these seemingly unsolved inconsistencies, Thorndike sees it hard to "find any probable associate of the study of Latin to cause the superiority in gain."

It was pointed out later that the above reports "contain erroneous measurements due to our over-estimation of the reliability coefficients of the two tests involved when given by classroom teachers, and our under-estimation of the effect of the unreliability of the tests in combination with differences between the mean initial ability of the Latins and that of the non-Latins." [22]

Thus corrected, the probable errors are too large compared with the superiority of Latins over the non-Latins as to render the result insignificant. All these mean that, according to the results of these investigations, those who study Latin for a year have an advantage so far as range of English vocabulary and ability in paragraph reading are concerned over those that do not study Latin.

Similar experiments have been made which give the same result. For example, Starch [23] in dealing with the general problem of the value of studying foreign language found that "the scholastic records of students in the university entering with Latin are only to a slight and negligible extent better than those of stu-

[22] Thorndike, E. L. The Gains Made in Ability in English by Pupils Who Study Latin and by Pupils Who Do Not. *School and Society*, 8:690, December 8, 1923.

[23] Starch, D. Some Experimental Data on the Value of Studying Foreign Languages. *School Review*, 23:697-703, 1915.

dents entering with German. Likewise, the scholastic records in modern languages, either beginning or advanced, or in English, of students entering with Latin are only to a very slight extent better than those of students entering with German. This slight difference is probably due to an inherent difference in the students rather than to a difference produced by these languages." [24]

Furthermore, "the English vocabulary of pupils who had studied Latin was 2.7 percent larger than the vocabulary of those who had not studied Latin in the case of university students, and 4.5 percent larger in the case of high-school pupils." The difference is "surprisingly small," however.

Further to substantiate his findings, Starch reported another investigation [25] to determine the effect of foreign language study in still another direction and to ascertain, if possible, how much of the difference in the performance of pupils with or without considerable amount of language study may be due to the actual training effect of the language study and how much may be due to a difference in the original ability of pupils. The finding goes to show that "the difference in the scholastic grades at the end of the first year of the high school between those who later pursued languages for a total of nine to fifteen years and those who pursued languages for a total of one to two years could certainly not be due to language training." And, incidentally, in the same paper a comparison is made of scores in sixteen different tests including ability in composition, number of words written, different words used, speed and comprehension in read-

[24] *Ibid.* p. 703.

[25] Further Experimental Data on the Value of Studying Foreign Languages. *School Review*, 25:243-48, 1917.

ing, etc., between Latin and non-Latin pupils. The difference is so small as to be negligible.[26]

Wilcox[27] attacked the problem in a rather unique way. We have noted in Thorndike's work that the difference between Latin and non-Latin pupils in their ability in English vocabulary and ability to read, is so small as to be negligible. The probable error renders the difference insignificant. Starch finds some superiority of Latin students over non-Latin students in several tests of which the abilities in the investigations of Thorndike are included.

Admitting that Latin students exhibit superiority over non-Latin students in the abilities mentioned, are we justified in claiming that the superiority is due to the study of Latin? Starch and Thorndike would say no, while others say yes. Starch and Thorndike claim that it is due to initial intellectual superiority of the Latin students. Wilcox attempted "to determine the validity of the two explanations by an inquiry into the initial abilities in English of Latin and non-Latin students. If the superiority in English of the classical students is due to the training secured in studying Latin, we should expect to find a greater superiority after the Latin had been studied than before, but if it is inherent and not the result of training there should be as great superiority in English grades before as after the Latin was studied."[28] This is a reasonable assumption. In order to test out this hypothesis Wilcox compared the median grades in English of students of Iowa City who studied German or Latin in the first year, second year, third year, and fourth year and drew two curves, one for those that studied Latin, and

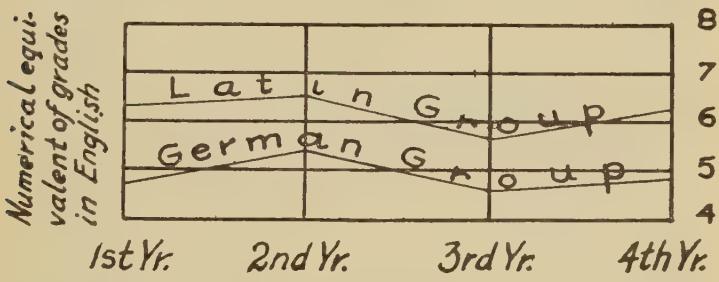
[26] *Ibid.* p. 244.

[27] Wilcox, M. J. Does the Study of High-school Latin Improve High-school English? *School and Society*, 6:58-60, July 14, 1917.

the other for those that studied German. The curves are here reproduced for comparison.

FIGURE VII

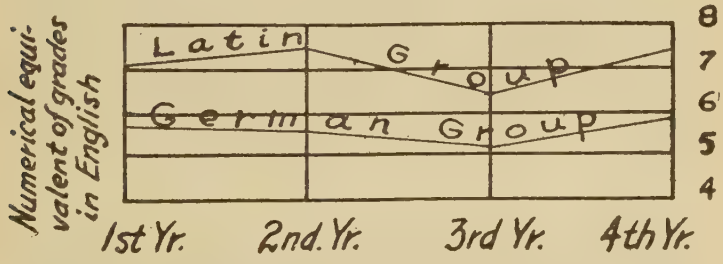
Median grades in English in the four successive high-school years of students taking Latin or German in the Iowa City High School. *(After Wilcox, p. 59).*



Another graph of comparison between those who studied Latin for two, three, and four years.

FIGURE VIII

Median grades in English in the four successive high-school years of students who had 4, 3, and 2 years of Latin in the Iowa City High School. *(After Wilcox, p. 60).*



All these curves show that there is as much difference in grades in English in the senior year as in the freshman year. They seem to show quite conclusively that so far as ability in English as determined by grades is concerned, those that study Latin do not have

[28] *Ibid.* p. 59.

a decided advantage over those that do not study Latin as a result of studying Latin.

The above investigations seem to show that training in Latin has very little or no effect upon English as claimed by Latin teachers and by those who believe in the disciplinary value of Latin studies. There are other experiments, however, which show that the effect of Latin upon ability in English can be increased tremendously if appropriate methods of teaching and selection and organization of subject matter are used. We will describe two of such experiments.

Haskell, Hamblen, and Coxe have made a notable contribution to the solution of the problems of transfer of training by providing or pointing to a solution of the problem of discrepancy of results in Latin experiments. What Winch and Johnson did to mathematics and Ruediger to neatness, they have done to Latin.

Haskell and Hamblen worked upon essentially the same problem, namely, "to determine the extent to which the effect of the study of Latin upon a knowledge of English derivatives can be increased by conscious adaptation of content and method to the attainment of this objective." To save space, Hamblen's study is here briefly summarized since his procedure and conclusions are essentially the same as that of Haskell. He divided the problem into four parts as follows:

"(1) To determine *scientifically* to what extent an increased knowledge of English words is attained by pupils who study Latin following the usual prescribed course of study with little or no attention to derivation.

"(2) To determine *scientifically* what further increase in English vocabulary, if any, is produced by the study of Latin derivation in the Latin class.

"(3) To indicate what effect certain kinds of text-books commonly used in ninth-grade Latin have on the attainment of an increased knowledge of English words.

"(4) To show the relative importance and comparative effectiveness of various teaching devices used in the experimental group in attaining an increased knowledge of English words." *(p. 13.)*

Two equivalent groups on the basis of I. Q. were established. The control groups or classes were taught Latin along the usual lines followed in most schools, little, if any, attention being paid to derivation of words. The experimental class or classes were taught in such a way that derivative work based upon a specific content and specific method was a conscious and definite aim of instruction. In this case we might say that the content of method of instruction is adapted to the end in view.

The results are overwhelmingly in favor of the experimental group as shown by results of both the Carr test (which consists of 25 words derived from Latin and 25 words of non-Latin origin) and the Thorndike Test which consists of 100 words of general vocabulary. The author concludes that "pupils devoting approximately one-fifth of the total class time to systematic work in derivation with the regular aid of notebooks and derivative lists incorporated preferability in text-books used and with occasional use of other devices to aid and give interest to the work, may be expected to *gain about three times as many Latin-derived words as Latin pupils not so taught.*" *(p. 46.)* The results with the Carr Test also show that the experimental group was superior to the control group in non-Latin words to the extent

of slightly one word, and the gain of the experimental in Latin-derived words is three times as great in the first semester as that in the control classes, and the year's gain of the experimental classes is twice that of the control classes. It might be said here that as measured by the Ullman-Kirby Latin comprehension test, "the special words in derivation given throughout the year in the experimental classes aided rather than hindered their progress in Latin." *(p. 29.)*

The influence of text-book material upon the year's gain in words derived from Latin is apparent in both experimental and control groups as follows:

TABLE XV

SHOWING INFLUENCE OF TEXT-BOOK MATERIAL UPON GAINS IN WORDS DERIVED FROM LATIN. (pp. 49-50)

School	Provision in text for derivation	Year's Gain in Latin Words	
		Control group	Experimental group
D	a little	3.55	12.0
B	fair amount	5.19	9.4
C	fair amount	5.88	8.2
A	none	3.23	8.1
E	none	3.09	3.7

In summing up the superiority of content and method used in the experimental classes, the author suggests five important elements: *(p. 50.)*

(1) Provision in text-books for derivation.

(2) Teacher's use of derivative list.

(3) Pupils' notebook where derivatives and Latin words are listed from time to time.

(4) Putting one-fifth of class time to study of derivation.

(5) Getting and maintaining pupils' interests through devices.

It is evident from this experiment that the automatic transfer of training from Latin to English is comparatively small; and that it can be increased three-fold or four-fold by proper selection and organization of subject matter and proper methods of teaching.

Dr. Coxe [29] set out to prove the validity of an objective in Latin as suggested by the American Classical League, namely, an "increased ability to spell English words of Latin derivation." Specifically he dealt with the following problems:

(1) Will Latin influence only those words which have been definitely related to Latin words studied?

(2) Are there principles which can be developed which will function in the spelling of English words of Latin origin which have not been studied?

(3) Is there any spread to words of non-Latin origin?

Dr. Coxe's answers to these problems are not dogmatic. It is much like Judd's answer, namely, it all depends upon how the subject is organized and taught. It can be so organized and taught that no transfer, or even interference takes place. But you can so arrange and present it so as to get a maximum of transfer.

The experimental procedure is worthy of note. Instead of the traditional two-group (control and experimental groups) method, Dr. Coxe has five, namely,—

Group I (Latin Control Group) made up of classes in beginning Latin in which no effort was made to relate Latin to English spelling.

Group II (Latin Experimental Group Alpha) made up of pupils of same grade as Group I, but different

[29] The Influence of Latin on the Spelling of English Words. *Journal of Educational Research Monograph*, No. 17, 1924. pp. 120.

in the sense that definite material was used to teach spelling. Teachers point out the similarity in spelling between the words in practice list and the Latin original place which the pupils were studying.

Group III (Latin Experimental Group Beta) made up of same grade of pupils as Group I and used same material as Group II but a different method was used. Here the teacher was expected to lead the pupils to develop rules and principles, besides pointing out the similarity of spelling between the Latin words and its derivative.

Group IV (English, non-Latin, Control Group) same grade as the Latin classes, no special effort to teach spelling.

Group V (Non-Latin Experimental Group) same as Group IV, used same material as prescribed for Group II and III, but followed a method which did not presuppose any knowledge of Latin and followed the best current practice in the teaching of spelling.

The groups are equated in general upon initial spelling ability although other factors such as intelligence and teachers were controlled as far as possible.

By comparison of these groups it was possible to determine:

(1) Whether there is any incidental (automatic) transfer from Latin to spelling.

(2) What advantage there is in pointing out the relation of Latin to English spelling, without the development of rules.

(3) Whether the use of principles and rules would result in any increased spelling ability.

(4) Whether greater gains in spelling can be made in an English class than in a Latin class.

Assuming that the measurement of the results is accurate, and we have every reason to do so on the

basis of the report, the following results and conclusions are obtained:

(1) "Latin as ordinarily taught in our schools today does not improve the spelling of non-Latin words. There is, in fact, a slight tendency for it to interfere with spelling of such words. . . . This interference is eliminated when the principles which govern the spelling of Latin derivatives are emphasized in the training."

(2) "The spelling of words derived from Latin can be improved through the study of Latin." The improvement is minimum when there is no effort to relate English words to Latin, that is, as Latin is ordinarily taught. This improvement is very much increased by better methods. A comparison of the special methods used leads to the conclusion that "merely pointing out the similarities in spelling between the Latin words and its derivatives, produces considerable gain, but not as much as when rules and principles are used"

These three studies of Haskell, Hamblen, and Coxe in Latin, those of Johnson and Winch in Mathematics, that of Ruediger in neatness, and that of Woodrow in memory are of tremendous significance to the whole problem of transfer of training. They all point to one conclusion that we get transfer of training from one study to another depending upon the method we use in teaching and organizing subject matter. In common with other experiments they show conclusively that the traditional methods of procedure and organization of subject matter do not result in much transfer. To the traditional questions: 'Does mathematics train one to reason logically?' and 'Does training in Latin help one in studying English?', we can not say a dogmatic yes nor a dogmatic no. All that we can say is

that it all depends upon how the subject is taught and organized.

Summary:—The upshot of the above discussion is simply that the findings of two or more investigators vary according to the method of procedure, the control of factors, the kind of training that the subjects undergo, and various other conditions that are involved in the whole complex process. The important thing to be noticed is that the amount of transfer can be very much increased if the conditions of transfer are present. These conditions favorable to transfer that we have discovered in the various experiments described above are: "Conscious formulation of general principles regarding techniques of procedure," "discussion and analysis of problems so as to arrive at general rules and ideas," "emphasis upon desirable traits as ideals," "better organization of subject matter and use of devices to arouse and maintain lively interest on the part of the pupils," and the like.

CHAPTER VIII

EDUCATIONAL IMPLICATIONS OF THE THEORY OF IDENTICAL ELEMENTS

UP to this point we were concerned primarily in attempting to show that experimental and theoretical evidence does not compel us to hold to specific activities since it is entirely possible, as we have pointed out, to demonstrate that by an appropriate control of conditions experience can be generalized. This we have shown by comparison of experimental procedures and results. In this chapter we are concerned in following this question of specific abilities in its educational applications.

The significance of the view that mental functions are highly specific has already been suggested. If it is true that mental functions are independent of each other, it would be a waste of time, energy, and money to teach a child to deal with one situation in order that he might be prepared to meet another situation. Consequently, education consists in equipping the individual with those items of knowledge, skills, and ideals which he will be sure to use in his life career. To put it differently, the emphasis in teaching must center upon the practical needs of life.

The emphasis upon the "practical" is a reaction against the over-intellectualism of the nineteenth century, and represents a definite tendency to bridge the gap between education and life. It is generally admitted that much of what we learn in school is not used in life outside of school. If you ask a person how often and in what connections he has found need of the facts that he had learned in algebra, history, literature, chemistry, or physics, you are bound to meet with a

characteristic response which indicates that you should not deal with the obvious. And this attitude is not without justification, and students of education must admit that even in teacher-training courses many of the facts learned do not find application in actual classroom situations. To Thorndike, Dewey, and others we owe a great debt for emphasizing the need of so organizing and presenting subject matter that it finds connection, not only with the present, but also with the future life of the child. The most important of the educational issues involved in the programs of the "progressive or experimental" schools is that of making school experience continuous with every-day experience; and we have every reason to believe that this is a problem which will continue to be paramount as long as we conceive the school as an agency for "conserving the past" and as "an instrument for progress and reform."

There is nothing wrong with the emphasis upon "practicality" as far as it goes. The only danger that we must guard against is the current tendency in conceiving it too narrowly, and we must admit that, when so conceived, it tends to degenerate into a type of education which is akin to the apprenticeship system. When one examines Professor Thorndike's text-books in arithmetic and junior high-school mathematics, the first impression that he gets is that there is a deliberate attempt to "parcel" out the science of mathematics in such a way that only those facts which are actually used in vocations are selected. The fundamental principle involved in the selection of subject matter is that of analysis of the social and business usage of the subject. This we see emphasized in his *Psychology of Arithmetic* and applied rigidly in his mathematical text-books.

Let us follow Thorndike in this matter of "practicality and business utility" as the standard basis of the selection of subject matter. He starts out with a problem such as "What are the functions that the elementary school tries to improve?" And he has a definite and, I should say, highly commendable answer, viz:

(1) Working knowledge of the meanings of numbers as names for certain sized collections, for certain relative magnitudes, the magnitude of unity being known, and for certain nuclei of relations to other numbers.

(2) Working knowledge of the system of decimal notation.

(3) Working knowledge of the meaning of addition, subtraction, multiplication, and division.

(4) Working knowledge of the nature of relations of certain common measures.

(5) Working ability to add, subtract, multiply, and divide with integers, common and decimal fractions, and denominate numbers, all being real and positive.

(6) Working knowledge of words, symbols, diagrams, and the like as required by life's simpler arithmetical demands or by economic preparation therefor.

(7) The ability to apply all the above as required by life's simpler arithmetical demands or by economical preparation therefore, including (7a) certain specific abilities to solve problems concerning areas of rectangles, volumes of rectangular solids, percents, interest, and certain other common occurrences in household, factory, and business life.[1]

The above analysis of the function of the elementary school in regard to the teaching of arithmetics is as good as can be made. We see in it a definite tendency towards the cultivation of intellectual interest in the field of arithmetic (emphasis upon meanings of numbers and number relations), and the promotion of social insight (emphasis upon meanings and their application to life). This is not at all surprising. Thorndike is a scientist himself and a devotee of intellectual

[1] *Psychology of Arithmetic.* Macmillan, 1922, pp. 23-24.

interests. And the very fact that he seeks to apply the science of psychology to the solution of educational as well as other problems in an inevitable result of his tendency to connect knowledge with life. No one can read his *Education* [2] without getting the impression that Thorndike's philosophy of the educative process is in accord with the best type that can be found.

We are then in complete agreement with Thorndike so far as the major purpose of education is concerned, namely, cultivation of intellectual interest and promotion of broad social insight. There still remains, however, the more important question of how he sets out to realize this aim, and we are inclined to think that his over-emphasis upon "practicality" does not make room for the cultivation of the values mentioned so that they may really be practical. Indeed, it is doubtful if intellectual interest is cultivated at all, except incidentally, and that any amount of social insight promoted is necessarily limited since intellectual interest is very essential for its maximum realization.

In order to determine the effectiveness of Thorndike's method of realizing the above aims, we shall first of all, examine his curriculum procedure. In the selection of material for arithmetic he makes use of what he calls "sociology' of arithmetic" which is exemplified in Wilson's study of the "social and business usage of arithmetic." [3] The study centers upon the attempt to find out just what use is being made of arithmetic in the country at a certain period, say 1919, when Wilson's study was made. As revealed by this study, "the majority of people in the great majority of their doings

[2] *Education, A First Book.* Macmillan, 1912, 281 pp.

[3] Wilson, G. M. A Survey of the Social and Business Usage of Arithmetic. Teachers' College *Contribution to Education,* No. 100. See also Thorndike's *Psychology of Arithmetic,* p. 24-26.

use only very elementary arithmetical processes. In 1,737 cases of addition reported . . . seven-eights were of five numbers or less. Over half of the multipliers reported were one-figure numbers. Over ninety-five percent of the fractions operated with were included in this list: ½, ¼, ¾, 1/3, 2/3, ⅛, ⅜, 1/5, 2/5, and 4/5. Three-fourths of all the cases reported were simple one-step computations with integers or United States money." [4]

Thorndike recognizes the significance of this study in the matter of selection of material for a course in arithmetic. It would be quite convincing to say that if, for instance, ninety-five percent of the fractions used in actual life is included in the list, ½, ¼, ¾, 1/3, 2/3, ⅛, ⅜, 1/5, 2/5, and 4/5, and the aim of teaching arithmetic rests upon its application to social and economic life, only these fractions need be taught to the child. The other and more difficult fractions such as 1/7, 1/9, 1/27, 1/6, and the like may be desirable to know, but "there are too many other desirable abilities" that need be acquired. This selection of material in terms of the practical usefulness of subject matter alone is carried out consistently in his text-books in mathematics. For example, in the Preface to *The Thorndike Arithmetic* we find the following fundamental statement, "Nothing is included merely for mental gymnastics. Training is obtained through content that is of intrinsic value." [5] We find the same principle at work in the *Thorndike Junior High School Mathematics.*

Consistently with this method of selecting subject matter in terms of intrinsic or immediately practical values, Thorndike sets out to teach this subject matter

[4] Cited by Thorndike in *Psychology of Arithmetic,* p. 24.

[5] Book One. p. v.

in such a way that the individual is equipped with specific habits or reactions to specific content. This is quite inevitable since all abilities are specific and independent of one another, that is, dealing with one type of content does not help in dealing with another content. Thorndike's emphasis upon the correct answer and his insistence upon going through the same operation, or slightly modified operation, as a method of proof are manifestations of the same tendency to establish fixed habits of operations with mathematical processes. Even reasoning and problem solving—thinking, are reduced to habits. In comparing mechanical habits and the processes that are involved in reflection or reasoning, Thorndike states, "On the contrary, I submit to you that *all reasoning we ever have is the organization, the upbuilding, of our habits;* that if we form the right habits, out of them will grow eventually this comprehension of the principles."[6] That is, if habits of thought are formed, thinking will take care of itself, and following the same argument, if the habits involved in courtesy such as raising one's hat to a lady, giving a seat to an elderly man, and the like, genuine courtesy will take care of itself. Knowing all the facts in history makes one able to reason historically, and being able to go through the motions in a scientific laboratory will eventually result in scientific attitude.

We do not need to go any further than these two aspects of Thorndike's educational practice to show that his method is short of realizing the aims set up, namely, intellectual interest and social insight. And we can suggest at this point that the reason why he

[6] Thorndike, E. L. Means of Increasing Efficiency in Arithmetic. Proceedings of the Conference on Educational Measurements, *Indiana University* Bulletin, Vol. XII, No. 10, September, 1914, p. 18.

will not promote these aims centers primarily in his failure to cultivate logical organization. We will elaborate upon this point later.

That logical organization is essential if knowledge is to be promoted and engaged in for its own sake, is a familiar fact. We go no further than in Thorndike's interest as a scientist. In spite of the fact that he is all the time applying psychology to education, he is all the while engaged in research, not for the purpose of getting material to be applied to education, but in order that he may promote knowledge in psychology and measurements as such. This attitude of disinterested study is perhaps best illustrated in his early studies especially in the field of animal psychology. Indeed, one need only read his three volumes of *Educational Psychology* to be impressed by his genius in organizing subject matter in a logical way so that further knowledge along the same line may be obtained. In these three volumes one forgets "practicality," and must forget it, in order to get the logical and finished consistency of the arguments—beginning with a treatise on the original nature of man and culminating in a treatment of individual differences and work and fatigue. Who will be bold enough to say that all the material in these three volumes is selected from the standpoint of practical application alone? The reason why these three volumes are used in advanced courses in educational psychology is that they represent a treatise of educational psychology as a science like an advanced course in physics or astronomy. No teacher, so far as I am aware, has ever tried to introduce the immature in educational psychology to these three volumes for the reason that they are highly theoretical, speculative, and logically organized. As a matter of fact, a prominent educator claims that Thorndike's

educational psychology is not as practical as it should be, for nowhere do we find treatment of the psychology of school subjects, such as reading, arithmetic, drawing, etc. as such.

We can go further here in saying that in his discussion of the various aspects of behavior, such as learning, individual differences, work and fatigue, transfer of training, and the like, he is not primarily interested in discovering, for instance, how one learns a specific subject, but in arriving at laws and conditions of learning in general. This discovery is not got by mere sampling of various learning activities, but by a distinterested thorough-going analysis and synthesis of the facts of learning in general. In other words, we have in his works a genuine example of logical organization at work in promoting and advancing knowledge for its own sake.

When we come to social insight, we find that logical organization plays as much a part as in intellectual interest. This is because intellectual interest is essential to broad social insight. There are two things that make a scientist great. One is his ability to promote his specialty without an eye to "cash values" that he might obtain. Another is his ability to apply the knowledge and attitude that he gets from his specialty to the intricate affairs of human relationship. What bearing does psychology have to education and social life? What does scientific attitude developed in the laboratory have to do with business relationship and citizenship? All these have to do with application, and we are inclined to the view that the important reason why Thorndike is a genius in applying psychology to education is that he has thoroughly mastered the field, that is, organized it in a logical way so that he sees the intricate relations of psychological facts to

other facts of life, such as education. In other words, his intellectual interest in psychology is a condition, a very important factor, of his interest in applying his knowledge of psychology to education. Purely verbal knowledge of psychology as the novice possesses it does not lend itself to application because it is not organized in a logical way by the individual that has it. This is not to say, of course, that possession of a real organized subject matter is equivalent to ability in application for we know of scientists who are not scientific outside their specialties. What we wish to point out is that logical organization and intellectual interest are very important factors in effective social insight.

In our discussion of Thorndike's method of selection of subject matter and teaching procedure, we have made the claim that Thorndike does not make provision for logical organization of knowledge which, as we have tried to show is essential for intellectual seriousness and broad social insight. First of all, learning a few facts about anything does not give one the ability to comprehend the whole. For instance, learning the fractions, ½, ¼, ¾, 1/3, 2/3, ⅛, ⅜, 1/5, 2/5, and 4/5, does not enable one to sense the meaning of fractions. Fractions, like the number series, have a logical organization. For example, 1/3 is between ½ and ¼, greater than ¼ and less than ½; is the sum of 1/6 and 1/6; is the product of 2 and 1/6; is the difference between 8/15 and 1/5, and so on. A fraction is unlike a whole number in that it it is only a part of a whole. If a child is taught only the above fractions, how will he know the relation of fractions to other number systems? How will he sense the fact that infinity is the quotient obtained by dividing $\frac{1}{0}$? What will he do when he comes to deal with negative numbers, as ⅓?

Let us give illustrations in other subjects such as geography. Will a geographer admit that specific information about various phenomena, such as day and night, products of different parts of the world, location of cities, and the like, constitute geographical knowledge? The fact is that mere possession of various items of information about the earth is anything but geography, because geography is a science that concerns the relations of the facts about the earth. Physics is the same. This relationship of facts cannot be obtained by learning facts alone, but by a process of organizing them in a logical way so that principles underlying them will result.

This system of logical organization does not result from habits, but in an effective guidance and organization of habits. In other words, habit formation and drill do not insure logical organization as Thorndike claims. In order to make room for organization of habits, we must make a deliberate attempt to control habits. Intelligence must supervise if we are to escape blind mechanism.

In the final analysis, the irony of it is that too much emphasis upon the practical is not practical because it does not make provision for logical organization which is the most practical way of insuring intellectual interest and social insight. To be sure, emphasis upon practicality is essential if we must keep education out of the rut of the purely technical and logical. But the practical must grow into logical organization of subject matter, and Thorndike does not make room for this. In fact, there is no room for it in his system.

What we wish to point out is that emphasis upon the practical is sound as far as it goes. The danger lies in not going further. It is entirely possible to begin

with the practical and end with the logical. This is exemplified in Breslich's scheme. In discussing the general idea of measurements including the use of formulae in finding unknown quantities, Breslich[7] begins with actual measurements of distances and proceeds to representation of these magnitudes and segments by numbers, and then by letters. In this way, the child gets an insight into the use of numbers to represent magnitudes, and the use of letters to represent numbers. Thorndike, to be sure, deals with measurements, representation of magnitudes by numbers, and literal representation of numbers, but he deals with these phenomena separately, that is, he does not organize them in such a way as to bring out their relationship.

In concluding this chapter, the reader should be reminded of the fact which we have indicated that Thorndike deliberately sets out to cultivate social insights, intellectual interest, and no less, logical organization. He himself is one of our strongest advocates of science for its own sake, and he, as much as anyone else, insists upon making the school continuous with life if not itself. There should be no mistake in the fact that Thorndike whole-heartedly subscribes to the democratic ideal in its entirety.

The problem that we have raised in this chapter is essentially this: Are Thorndike's theory of the learning process and his practice in the organization of subject matter and the method of presentation he advocates, consistent with the democratic ideal? In other words, will he get the results that he sets out to achieve? Our contention is that a mechanistic conception of behavior, over-emphasis upon habit formation and drill, and confinement to the practical are in

7 *Junior High School Mathematics.* Macmillan, 1924, Chapter I.

themselves opposed to logical organization, for by logical organization we imply flexibility and modifiability as versus flexity and mechanism, constant looking beyond the present need as over against emphasis upon the practical, and thinking as over against habit formation. And inasmuch as logical organization is the most important condition in promoting social insight and intellectual interest, it is our belief that Thorndike will not and cannot promote them to the maximum of their extent and fullness with the method he adopts in achieving them.

In passing, we wish to point out that the practical which Thorndike is insisting upon, the habits which he wishes to establish can be better achieved by a method such as proposed by Breslich. Begin with the practical (psychological) and the manipulation with objects, but proceed to the logical organization of knowledge and skills. In other words, we recognize Thorndike's scheme to be sound as far as it goes, but it must go further than mere practicality. Transcend the limitations of habits by making them servants of thinking, and you have a system which not only makes for the cultivation of the democratic ideal but for the accomplishment of the practical more fully and efficiently as well. In other words, extend the practical from the immediate to the remote by cultivating appreciation of values other than the bare necessities of life, and you will not only make the immediate more practical but you will also increase the realm of immediacy, thus bridging the gap between the remote and the immediately present. This is what we mean by saying that the most theoretical (logical organization and deductive thinking) is really the most practical if done properly.

PART TWO

A RE-INTERPRETATION OF THE PROBLEM OF TRANSFER OF TRAINING

CHAPTER IX

A RE-INTERPRETATION OF THE PROBLEM OF TRANSFER OF TRAINING

UP to this point we have tried to show that Thorndike has not given us a theory which explains how transfer takes place, and which, when applied, gives us a type of education which is compatible with the democratic ideal. This failure to explain transfer of training lies primarily in an erroneous interpretation of the nature and function of mind and intelligence. With a mechanistic conception of behavior, intelligence becomes the sum or average of mechanical habits. In other words, by explaining intelligence that way Thorndike had really explained it away. His procedure is like that of the behaviorist, who, not knowing how to explain the nature of mind, and to avoid the trouble and discomfort of not being able to explain it, simply denies its existence. And as soon as we have explained mind and intelligence away, we have thereby sidestepped or begged the question of transfer since transfer is just another name for intelligence.

Of course, whether we like it or not, transfer and intelligence still exist, and consequently, the burden of explanation is placed at our door. We have demonstrated by the results of experimental investigations that transfer takes place to the extent in which conditions favorable to transfer are present. This fact has been shown by Judd, Johnson, Ruger, Woodrow, Winch, Ruediger, and several others.

As stated above, Thorndike failed to explain transfer because he started at the wrong end. By denying transfer in the sense that we understand the term, he

tried to make out a case for something which we do not call transfer. Transfer in the ordinary sense, and the sense in which it is used in this paper, involves flexibility of response which is wholly incompatible with a mechanistic conception of intelligence. Consequently, doing over again what we have done before in another situation is not transfer, since it is nonsense to say that training to add $2 + 3$ is transferred to ability in adding $2 + 3$.

In order to re-interpret the problem of transfer, therefore, it is necessary that we first define its implications. As stated above, transfer and intelligence are synonymous terms. If that is the case, transfer implies at least three things. The first we have already mentioned namely, flexibility and modifiability of behavior. Secondly, simultaneously with the change and modification of reaction is a corresponding change in the experienced environment. In the third place, where the environment is purely physical and the reaction is a simple reflex or mechanical habit, we have no problem of transfer. In other words, the phenomenon of transfer is present only where there is a conscious adaptation of means to ends.

These implications of transfer have tremendous significance in our discussion of the nature of behavior and of the environment. For Thorndike every situation is ultimately reducible to a physical environment, a thing-in-itself, which changes only according to physical laws, and which differs from other environments only in the degree of complexity, that is, in the number and arrangement of its component situation-elements. Consequently, all behavior is reducible to automatic or mechanical habits, instincts, and reflexes varying with each other only in the number, arrangement, and strength of the specific responses that make up the

total reaction. As already stated, intelligence is the sum or average of mechanical habits.

In order to face squarely the real issue in transfer it is our aim, first of all, to re-consider the nature of environment and intelligence. The fundamental postulate that we propose to defend is that there are two kinds of environment and two types of reactions. One kind of environment is an unchanging physical state which is affected only by ordinary physical laws. The reaction that is appropriate to it is of the reflex, instinctive or purely habitual type. The other type of environment is a meaningful one, one which is constantly changing, and corresponding to which, is a conscious or intelligent reaction characterized by its flexibility and modifiability according to the changes that take place in the experienced situation. In our discussion of transfer we are not to be concerned with reflexes and automatic habits. We will confine our treatment to the meaningful or experienced environment and to the conscious or intelligent aspect of behavior which is guided by meanings. This is indeed the most common fact of experience. As Dr. Bode says, "We avoid a mud puddle, not because we are born with a reflex for mud puddles, but because it means wet feet; we reach for the apple because it means something to eat; we take our umbrella because the sky looks like rain . . . If the moth, as a result of previous happenings, were capable of comprehending the meaning of the candle, the tendency to fly toward the candle would be suppressed, and adaptive behavior would be secured by means of a different reflex or adaptive behavior; viz, that of withdrawal." [1]

That behavior is guided by, and changes simultaneously, with meaning is apparent even in the case

[1] Bode, B. H. *Fundamentals of Education.* Macmillan 1921, p. 151.

of lower animals such as chimpanzees. Koehler gives several illustrations to the effect that these animals act with reference to the functional aspect of objects. For instance, a situation was so arranged that a chimpanzee was confined in a cage, with a banana placed out of reach, and with nothing like a stick (which the animal was accustomed to use in securing the fruit) at hand. At the rear of the cage, however, there was a desiccated tree, branches of which could easily be broken off and used as sticks. Seeing the tree, the animal ran towards it, broke off a branch and used it to get his fruit.[2]

In another experiment[3] which Koehler calls the 'double-stick experiment,' the situation included "a chimpanzee confined in a cage, a banana placed out of reach, and two bamboo sticks, one smaller than the other lying close by. Each of the sticks was too short to reach the goal. One stick could, however, be fitted into the other, and when thus put together the tool would be of adequate length. The brightest of all the animals, Sultan, was the subject. He began like all animals do with random movements. Among other things he stretched one stick as far as possible in the direction of the fruit, and then carefully pushed still further by the second stick until the goal was actually touched. Thus a contact was made with the goal, but unfortunately one that did not bring the desired result. Several other attempts were made, but all in vain."

"Koehler gave up the experiment and departed. The keeper, however, observed the animal a little further. Sultan continued aimlessly to manipulate the sticks

[2] Koehler, W. *Mentality of Apes.* Harcourt, Brace & Company, 1927, pp. 103 ff.

[3] *Opus cit. p.* 125 ff.

and by so doing it happened by chance that he "held one stick in each hand in such a way that they came into line with one another. He then placed the smaller one in the opening of the larger, sprang at once to the bars, toward which his back had previously been half-turned, and began to draw in the banana towards him.[4] The experiment was repeated the next day, and while Sultan began with useless reactions as at the beginning, he fitted the two sticks together in a few seconds and obtained the banana.

Here we have two cases in the lower animal in which meanings operate in directing behavior. A purely mechanistic explanation—viz. trial an error method of learning, as Thorndike would undoubtedly offer, would be inadequate. When we consider the speed with which the problems were solved, we see a great difference between the curves of learning in these cases and those in which trial and error was the dominant characteristic of the way learning takes place as, for example, Starch's 'mirror drawing experiment.' [5]

We see very clearly that in the first experiment the branches of the tree had to be transformed into 'sticks,' that is, they took on the meaning of 'stick-ness' before they were used as tools. In the second experiment, the two sticks coming into line with one another meant a "longer stick," and this meant a banana to eat. Notice that the quality "longer" stick was put into the situation "two sticks fitted together" just as "stick-ness" was put into the branches of the tree. In other words, the situations underwent an enormous transformation. Notice also that simultaneously with the changes in the objects there were corresponding modifications of

[4] Koffka, K. *The Growth of the Mind.* Harcourt, Brace and Company, 1924, pp. 198-99.

[5] Starch, D. *Experiments in Educational Psychology.* Macmillan, 1917, Chapter VIII.

behavior. Before the branch of the tree was transformed into a stick the animal behaved towards it just as he always did to branches of trees as such. At first the tree was just like another tree, but now it becomes another object—one of which the parts can be used as sticks. The branches took on new meanings so that instead of being just branches they are now 'sticks-to-get-a-banana-with.' The tree which used to be an object of indifference now becomes of interest to the animal. It elicits looking and consequent breaking off a branch and using it like any other stick.

The same transformation of behavior took place in the 'double-stick experiment.' Before the meaning 'longer-stick' was perceived, the animal behaved toward the two sticks as 'sticks-that-are-inadequate-or-too-short-to-get-a-banana-with.' But now that the animal sees a longer stick in the situation he behaves accordingly and gets the banana.

In the case of man, as we have already pointed out, the control of behavior by meanings is exceedingly common. Snow means cold feet, and therefore wearing rubbers. When the telephone rings I take off the receiver and say 'hello' because it means that some one wishes to talk to me. When the doorbell rings I open the door because it means that there is some one at the door wanting to come in. When the leaves of trees begin to fall, I send my winter apparel to the cleaners because it means that winter is approaching. As in the case of the animals, my reactions change with the change in meanings of the objects or situations. Before I ever had any experience with or had heard anything about snow, I had no idea of wearing rubbers, and consequently, if confronted by snow I would not have put on my rubbers. Before I knew the meaning of the telephone, the ringing was just a sound, and the

same is true with regard to the door-bell. In the course of experience, however, I have learned to react differently, that is, my reactions have undergone transformation concomitantly with the change in the meaning of the situations.

Let us take a more complicated case such as Newton's discovery of the law of gravitation. Tradition has it that Newton, as he sat in his beautiful garden at Wallsthorpe one afternoon in the fall of 1666 saw an apple fall to the ground and this suggested a great truth to him—namely, that all particles of matter in the universe exert an attraction on one another, the magnitude of which is directly proportional to their masses and inversely to the square of the distance between them. So goes the story. Whether or not it is true (and many authorities consider it authentic and entirely reasonable) does not matter much for our purpose. What we are primarily interested in, is the way the suggestion came about.

The first thing to notice is that the apple acquired a meaning which it did not have before—namely, a 'falling body' which attracts the earth and is attracted by the earth. Likewise, the earth, the moon, and the other planets acquired a new meaning. The earth and the moon are identified with the apple as falling bodies. The earth falls toward the apple just as truly as the apple falls toward it. The only reason why we do not recognize this fact is that the mass of the earth is so great that its motion with relation to any small object is imperceptible. When we say that the moon and the earth are identified with the apple as falling bodies, we mean that the notion of falling is applied to the moon and to the earth. This application, however, is not wholesale; that is, the notion "falling" has to be reinterpreted because, as a matter of fact, the moon

does not actually fall toward the earth in the same way that the apple does. Falling, in this instance instead of meaning absolute down, is made to refer to the tendency of two bodies to attract each other, or more simply, to the tendency to fall.

So far, we have given detailed accounts of three cases in which meanings operate in controlling behavior. One important thing to be noticed in all of these cases is that the reason for changing the reaction and the situation is that both the situaion and the reaction are confused, that is, unsatisfactory. This is merely another way of saying that there is a problem which needs to be solved by making the stimulus adequate and correspondingly, by making the reaction adaptive. It is this making of the environment a better one and the making of the reaction satisfactory that constitutes intelligent behavior.

When the chimpanzee could not secure the banana he was facing an unsatisfactory or inadequate situation which had to be changed or made over in such a way that he could get the banana. There was either no stick or else the stick was too short and the banana was too far away. The problem was to get a longer stick to draw the banana with. The situation could be rearranged in order to make it satisfactory, which means that changing it would make it adequate. Thus, the branch of the tree could be broken off and used as a tool, or that two sticks could be broken off and used as a a longer stick. Newton was likewise confronted by a difficulty, namely, that of establishing identity between the apple and the moon. Such problems as 'why does not the moon fall to the earth or the earth to the moon,' 'why, if the earth and the moon pull each other there was no collision—these problems had to be solved by a remaking of the situations. For instance, the earth

and the moon were made 'falling bodies that did not quite fall' or that only 'tend to fall.'

This unsatisfactory state of the situation is always accompanied by a corresponding unsatisfactory status of the reaction, since unsatisfactoriness of the situation does not exist apart from unsatisfactoriness in the response. In other words, when we have a problem we mean just that state of affairs in which both the situation and the reaction are in a mess.

This brings us to the problem of meaning and datum. We define meaning as that which is pointed to or suggested by an object. The branch of a tree suggests a stick and putting together two sticks to a longer stick. The clouds point to rain and getting an umbrella, and the mud puddle suggests wet feet. When the situation and the response are unsatisfactory there is a tendency for the meaning and datum to be separated. The situation suggests or points to something that was not there before. The apple in Newton's case suggested a falling body which is attracted by the earth and which attracts the earth. The solution of the difficulty took place in Newton's case by detaching the suggested object or meaning and dealing with it as if it were a thing. Falling was thus detached and studied as to its properties. Falling was re-interpreted so that instead of absolute down, it became a name for the tendency of two objects to pull each other. Furthermore, these detached meanings are applied to a great many situations. Falling is applied to the earth and the moon. This process of application, as stated above, is not wholesale, that is falling is not applied unmodified to the moon and the earth because these bodies unlike the apple do not actually fall in the sense that falling refers to absolute down. This process of detaching meanings, re-making them as they

are applied to new situations is what we call concept formation. A meaning then that is detached from its datum, reorganized in the process of application to new situations, and given a name is what we call a concept. For instance, 'gravitation' is a concept—it is not a thing; it is a meaning detached from the notion of falling bodies, enriched in application and provided with a name.

This ability to form concepts is evidently the distinguishing characteristic that sets off man from the lower animals. Man, as one author puts it, is man by virtue of his ability to deal with abstractions. No animal psychologist has yet found convincing evidence that animals detach meanings from data. In the case of the chimpanzees there is no ground for believing that stick-ness or "longer-stick-ness" were detached from the particular sticks in the same way that falling was detached from the falling apple. The tree had to be desiccated in order for the animal to see the meaning stickness in its branches, and the two sticks had to be put into line with one another before longer-stick-ness could be perceived. In the case of normal human beings, the tree need not be desiccated and the two sticks need not be put into line with one another in order for them to point respectively to stick-ness and longer-stick-ness.

When we recognized the above facts of behavior, the guidance of reaction by meanings, the making over of the reaction and situation simultaneously to establish a satisfactory state of affairs, the formation of concepts by detaching and applying meanings to new problems or situations, the phenomenon of transfer is very greatly clarified. And we can define and describe it simply as that process of extending and applying meanings to new problems or situations in order to solve

these problems and to make the new situations satisfactory. In other words, one transfers his previous training to the solution of new problems in proportion to his ability to modify his behavior in accordance with the changes in the environment to make adaptatoin of means to ends possible and efficient.

The champanzee transferred the meaning stick-ness to the branch of the tree and longer-stick-ness to the two sticks fitted together. This means that the range of the meaning of stick-ness has increased so that besides an object as the animal ordinarily used as a stick, the branch of the tree was also considered or taken to mean a stick. When we say that transfer is narrow in animals, we mean that the meanings that animals perceive are narrow in their range of application. The reason for this is that tool-ness, stick-ness, and longer-stick-ness are just perceptual meanings, that is, they are never detached from the particular objects to which they inhere. To put it differently, these meanings are not detached and dealt with apart from their data as concepts. If tool-ness is thus detached so that any object that possesses the same characteristic as not only that of a stick, but of anything that can be used as an instrument for securing an end in view, then its range of application or transfer is definitely increased. A tool varies all the way from a stick to get a banana to the three R's and further. Even ability to transfer becomes itself a tool for better adjustment. Intelligence is also a tool to get more knowledge and to gain more insight into the intricacies of our civilization, if so used.

The bearing of the development of meanings, concepts, and generalization upon the extent or amount of transfer is evident in the experiments which we have already described. In criticizing Thorndike's re-

sults we pointed out that the reason why he got a very limited amount of transfer was primarily that of lack of conditions favorable to transfer. For example, in his experiment on 'the effect of changed data upon reasoning,, it is quite evident that the subjects only had verbal knowledge of algebra. No generalization was formed and no algebraic concepts were developed so that at the end the subjects could not transfer their knowledge of solving the problem, 'Find the square of $(x + y)$, to the solution of 'Find the square of $(a_1 + b_1)$.' Again, in the experiment on the influence of training in the estimation of certain magnitudes upon ability to estimate other magnitudes, the training was merely routine, that is, no attempt was made to develop general principles or concepts of method. The same is true with regard to the other experiments in which training is just routine and repetitions.

The fact that I am trying to point out here is that if the experiment is so controlled that the result of training is mechanical habit and nothing more, there is very little or no transfer. In some cases, as illustrated in Bergstrom's experiment, habit interferes with subsequent training to the extent in which the habit has been fixed. A survey of the experimental investigations, such as I have attempted, will reveal the fact that most of the experiments deal with transfer of mechanical habits, and I venture to say that this is the reason they did not get any more transfer. Very few experiments indeed have been so planned that meanings, concepts, and generalization of method of procedure have been developed, and it is in these few experiments where we find considerable amount of transfer. We have illustrated this fact in Chapter VII in which we discussed several groups of experi-

ments that deal with the same or very similar problems.

In order further to substantiate our claims that dedevelopment of meanings, concepts and principles or generalizations facilitate transfer, we refer the reader back to our discussion in Chapters VI and VII, particularly to the experiments by Woodrow, Meredith, Winch, Ruediger, Judd, Coxe, Ruger, and Johnson. We recall that Woodrow and Meredith had three groups of subjects, a control group, a practice group, and a training group. We have noticed that where practice was merely drill, there was no transfer, but where there was a conscious formulation of technique and attention was directed to meanings (that is, of words and poetry in Woodrow's experiment, and of the characteristics of definitions in general in Meredith's experiment), there was considerable transfer. In Winch's and Johnson's experiments on transfer of mathematical reasoning to reasoning in general we have found that where there was a conscious development of principles and discussion of results in the light of facts, there was evidence of considerable transfer. In Winch's experiment, for instance, the pupils did not only solve the problems, but they had also considerable training in testing out their answers, whether they were right or wrong. Johnson did the same thing in geometry in his attempt to apply Dewey's five steps in thinking. If we compare the procedure in these experiments with that of Van Fleet and Lewis, we find that the difference is just in the control of factors such as indicated.

What is true in memory and mathematics is true in other fields. Take Ruediger's experiment in which he modified the technique of Squire and Bagley in the problem of transfer of neatness. Ruediger directed

the teachers "to talk *with class* (not *to*) on the importance of neatness in dress, business, the home, hospital." Notice the extension of the ideal of neatness to other fields. And, contrary to the findings of Bagley and Squire, Ruediger found considerable transfer of neatness from one subject to another. Apparently the same principle is found to work in Huger's experiments with puzzles. The influence of concepts is perhaps best illustrated in Judd's experiment which we have already described. Where the concept of refraction was developed there was considerable transfer from training in hitting a target twelve inches under water to hitting targets four inches under water. Those subjects who merely practiced in hitting targets and had no knowledge of the phenomena of refraction did not profit by the training.

Perhaps the most practical experiment that has been made in which the relation of meanings, concepts, and principles to the amount of transfer is shown conclusively is that of Coxe. His problem was to find the 'influence of Latin on the spelling of English words.' We recall that he had three training or experimental groups. One group was taught Latin without pointing out the relation between Latin and English words; to another group was pointed out the similarities and dissimilarities between Latin words and their English derivatives; to the third, besides knowledge of relationships between English and Latin words, they were taught to generalize these relationships and to establish rules and principles governing them. The findings are that the first group gained very little in the final test; the second group showed no gain but slight interference; but the third group showed considerable transfer.

These experiments are enough to show that development of meanings, concepts, and generlizations fa-

cilitate transfer. In fact, we are willing to go as far as to state that they are the most favorable conditions if not the only conditions favorable to transfer. When meanings are enriched there is a corresponding increase in the chances that experience is tied up with other things. When meanings are detached from their concomitants and applied to varying situations, the amounts of transfer is tremendously increased. We have illustrated this fact in our comparison between chimpanzees who do not detach meanings to that of the human being who has this power of abstracting qualities from experienced objects and applying them to other situations.

The educational significance of this notion of transfer is tremendous as well as evident. If transfer is ability to extend and apply meaning to new problems or situations, then education becomes a process of cultivating meanings in such a way that their range of application is enormously increased. This is another way of saying that education is concept building, for concept formation is just that process of enriching a meaning or increasing its range of application. Thus the concept of evolution which is developed in biology can be infinitely enriched in its application so that, like the woman's hairpin, it can be used for a great many other purposes than that for which it was made. If the individual sees evolution in other fields besides in biology, his insight becomes increased. For example, knowledge has its own evolution; the school has undergone a tremendous change; everything on earth and under the earth has evolved and is in process of evolving. And, as soon as you have extended evolution this far, you can easily point to the fact that life is evolving—it is an experiment, in other words. And if, together with this concept of evolution there is

promoted a sense of man's power to alter our institutions so as to make them better, we would have equipped the individual with the raw material that will make possible the enrichment of experience and the cultivation of intellectual interest.

We sometimes call education a process of world-building which means making over our present world to a better world. This is a process both of understanding man in his various and intricate relationship with one another, and of ability to make over the environment to promote such understanding. The world is what we make it or that life is what it means to us. It may mean very narrow vocationalism, or it may mean a life which is enriched in meaning—a life which is more than a vocation and more than scholarship. It is a life which penetrates into the deepest realm of appreciation, open-mindedness, sympathetic tolerance and moral, intellectual, and spiritual values. It is a life which realizes the democratic ideal in its entirety —social insight and intellectual seriousness.

We said above that education as world-building or concept forming involves understanding of our fellowmen as well as of being able to transform our environment to make it a better environment. In other words, it is a process of re-making of behavior simultaneously with the reorganization of the environment. This process we call thinking. It is a process of getting and testing new meanings. The school, then, becomes an agency for the cultivation of thinking and not merely an institution wherein the individual gets miscellaneous information and acquires specific skills.

When education is so conceived—concept building, world building, and training in thinking, we may be sure that it is fulfilling its function in a democratic society, namely, that of facilitating progress and reform.

CHAPTER X

SUMMARY AND CONCLUSION

THE purpose of this paper has been, as indicated by the title, to make an extended and critical analysis of Thorndike's theory of identical elements and to reinterpret the problem of transfer of training. It is our contention that the doctrine of identical elements either does not give us a satisfactory explanation of how transfer takes place, or else, it over-simplifies the process of transfer to such an extent that the problem of transfer entirely disappears.

We have noticed that Thorndike based his theory upon the assumption that mental functions are highly specialized. This assumption, however, was found to be highly questionable. If by specific ability Thorndike means a subdivision of a faculty, he is back to faculty psychology and formal discipline. On the other hand, if he makes each specific act dependant upon an equally specific ability, the problem of transfer disappears, since learning to perform a specific act does not help in learning to perform any other act. But it is an obvious fact that we use old experience in dealing with new situations, and merely to account for this by saying identical elements is to state the fact and not to explain it.

We have found that however fruitful the theory of identical elements has been in initiating and encouraging scientific experimental procedure as a method of solving the problem of transfer, it does not square with reliable experimental evidence, including that which is offered by Thorndike himself. It has been pointed out that in many instances as exemplified in connection with the principle of proportional transference the

theory is not supported by the results that Thorndike obtained; and where the experiments show that mental functions appear to be highly specialized, we have given evidence that this is due to the nature of the experiment. That is, if the conditions of the experiment are so controlled as to place the emphasis on the development of specific reactions to specific stimuli, the outcome will inevitably be specific and mechanical habits, which makes it appear that mind consists of discrete and independent mental functions. On the other hand, if the conditions of the experiment are so altered as to introduce favorable conditions of transfer, such as conscious adaptation of means to ends, formulation of laws and principles, discussion, analysis, and organization of experience to fit the demands of the new situation, the results of experiments are pretty sure to indicate that mind and intelligence are not divisible into small bits of particular abilities which are insulated and independent of one another, but that they represent a unitary and highly integrated system of adaptive and flexible forms of behavior.

To offset Thorndike's evidence that mental functions are highly specialized, and to substantiate our claim that such functions may be generalized, we have offered evidence from the experiments of Judd, Ruger, Ruediger, Coxe, Woodrow, Meredith, and others. These investigators have shown that the amount and range of transfer which one might obtain depends very greatly upon the presence of factors and conditions that are favorable for the occurence of transfer.

It has also been indicated that, when applied educationally, the theory of identical elements does not make room for the logical organization of knowledge and skills, which is an essential condition of intellectual growth and broad social insight. No provision is made

by Thorndike for disinterested study, for the acquisition of knowledge for its own sake. Furthermore, the tendency to limit the individual to certain definite skills and information shuts him off from the opportunity for extensive self-realization and self-expression through the medium of what we call social insight. Merely to know certain facts concerning literature, science, and the arts, does not carry us very far in cultivating human values which we call appreciation, sympathetic tolerance, and open-mindedness in dealing with other people, and with the other nations and races of mankind.

These three objections to the theory of identical elements (inability to explain how transfer takes place, failure to square with reliable experimental evidence, and incompatibility with our ideal of democratic education) have their basis in fundamental misconceptions as to the nature of mind and intelligence. We have pointed out that a mechanistic interpretation of intelligence is a contradiction in terms. That is, in attempting to explain intelligence on the basis of mechanical habits alone, Thorndike has explained intelligence away. And inasmuch as transfer is synonymous with intelligence, the problem of transfer is likewise explained away. Intelligence and transfer imply flexibility and modifiability both of behavior and of the experienced environment, whereas mechanical habits and reflexes, on the one hand, and the situation-elements postulated by Thorndike, on the other hand, are treated is fixed unchanging facts. In re-interpreting the problems of transfer of training, therefore, we took as our point of orientation a conception of mind and intelligence which, in our belief, squares with what we find in actual observation and experimentation. We have assumed that there are two types of behavior

or reaction corresponding to two kinds of environment. One is automatic, reflex, or mechanical habit, in response to an unchanging environment; and the other is intelligent behavior in a meaningful and highly modifiable situation. In our problem of transfer we are concerned only with the second type of behavior (intelligent) and the second kind of environment (meaningful). We have also made the claim that the reaction and the situation change simultaneously; or, to put it differently, the reaction and the situation and the changes therein are parts of the same process. Illustrations were given from animal as well as human behavior of the familiar fact that behavior is controlled by meanings just as surely as changes in meanings are conditioned by simultaneous changes in behavior.

When we say that in transfer we are concerned only with itelligent behavior, we are not to be understood to imply that habits are of no importance in transfer. In all intelligent behavior we utilize habits, but these habits are controlled and re-directed by meanings. This is the essence of the statement that reactions and meanings change simultaneously in the process of adjustment.

When we say that behavior is unsatisfactory, it is because we realize that the situation is inadequate. Consequently, in the process of adaptation of means to ends two changes are made, namely, a change in the reaction and a simultaneous change in the environment. This power of remaking the reaction to make it adaptive and of the situation to make it satisfactory is what we call intelligence. In this process we utilize previous experiences—meanings and reactions. Transfer, then, is to be defined as the extension and application of meanings to new problems or situations in such a way that we can deal with them effectively.

If that is the case, the amount of transfer depends upon the extent to which meanings are identified and applied. This range of extension is much widened by the ability of the individual to detach meanings from their concomitants. The process by which they become detached is also a process by which they become enriched in content. The meaning thus developed is then provided with a name; and in this way meanings become concepts. Transfer then is very greatly facilitated by the formation of concepts.

The educatidonal significance of this notion of transfer is clear and unmistakable. If transfer is facilitated by concept formation, then education, in order to facilitate transfer, must of necessity be concept building. It is a process of equipping the individual with concepts which are rich in meanings so that he can apply them in meeting various life situations. When so conceived, education becomes world building, in as much as our world is what we make it or what it means to us. Our knowledge of any subject when generalized into concepts and enriched in content and application becomes a tool for adjustment to an unlimited number of situations. Knowledge thus becomes a tool both for practical purposes and for broad social insight, for to see the application of knowledge to various lines of activities is synonymous, so far forth, with appreciation of the social significance of these activities.

To say that education is world building implies the power to re-make one's world, for our store of concepts are not mere accumulations of meanings. Acquiring a concept is not a merely additive process, like Ford's getting another million. Concepts interpenetrate, and it is by their interpenetration that they are made over and enriched in content. In other words, the ability

to develop concepts implies the power to re-make them from time to time, and in this process of re-making both the experienced environment and the bodily reactions are transformed. From this standpoint, education becomes training in thinking and logical organization, and not merely habit formation and drill; and learning is not merely analysis but involves synthesis as well.

In conclusion, the writer wishes to state that the theory of transfer which he has proposed is an interpretation that needs to be tested out more fully in actual practice by a thorough-going and adequately controlled experimentation and open-minded observation of actual results in the classroom. Thorndike's advocacy of experimentation is thoroughly sound, but if this experimentation is to be enlightening, the procedure must of necessity be modified considerably. Emphasis should be placed upon the method of training the subjects for transfer for the purpose of discovering the most favorable conditions of transfer. This form of procedure is illustrated in the investigations of Woodrow, Coxe, and Meredith.

In the meantime, there is sufficient reason to urge that thinking and concept formation should be stressed more in the schoolroom. Such emphasis would in itself constitute a partial test of the hypothesis here proposed, and it would also furnish a point of depature for a reorganization of our school system for the furtherance of intelligent participation in the life of the community. Thorndike's emphasis upon the practical and immediate interest of the child is indeed essential, but there is no warrant for the notion that education can be satisfied merely to equip the individual with specific items of information and specific skills. The child should be led to organize his ex-

perience in a logical way so as to make room for the promotion of knowledge and for the development of broad social insight. As the child learns and organizes what he learns he should at the same time be encouraged to apply his learning to various situations. There is no better way to insure transfer than to give the child an opportunity to apply his knowledge to the re-interpretation and re-organization of his daily experiences.

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